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Shrivastava

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(54) **IMPLANTABLE LUMEN FILTER WITH
ENHANCED DURABILITY**

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604/104–107
See application file for complete search history.

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Primary Examiner — Katrina Stransky

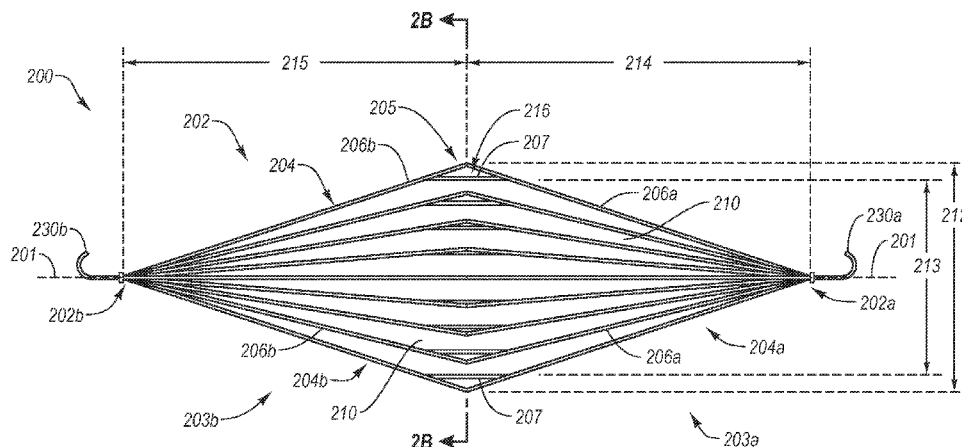
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ABSTRACT

An implantable lumen filter (100) is described. The implantable lumen filter includes a proximal portion (103a) having a generally-tapered outer surface defined by a plurality of outer struts (106). The implantable lumen filter may also include a distal portion (103b) having a generally-tapered outer surface defined by a plurality of outer struts (106b) coupled together at the distal end (102b) of the distal portion. The implantable lumen filter may also include an apex (105) comprising the connection between the proximal and distal portions. The apex may define an outer dimension of the implantable lumen filter. The outer surface of the proximal portion is dimensioned to direct particulates towards the outer dimension.

14 Claims, 16 Drawing Sheets



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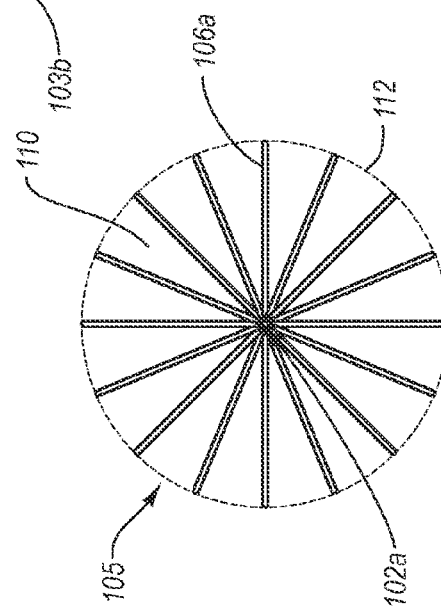
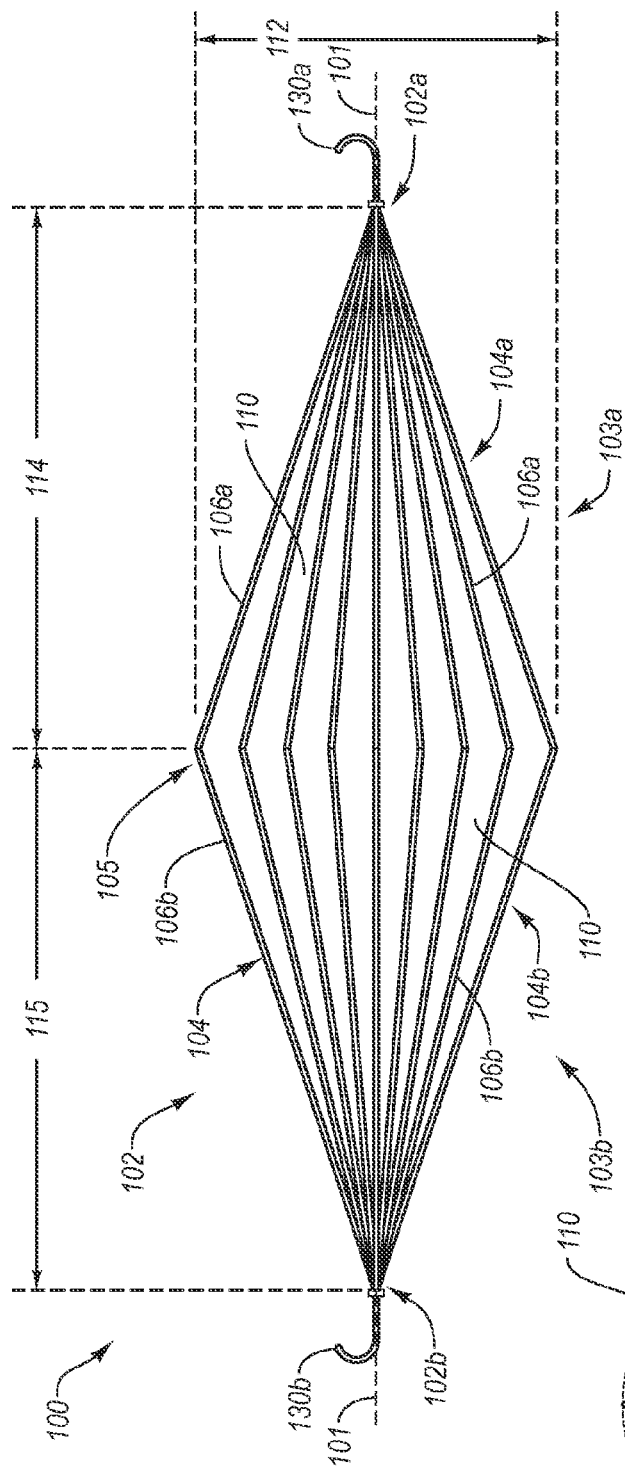
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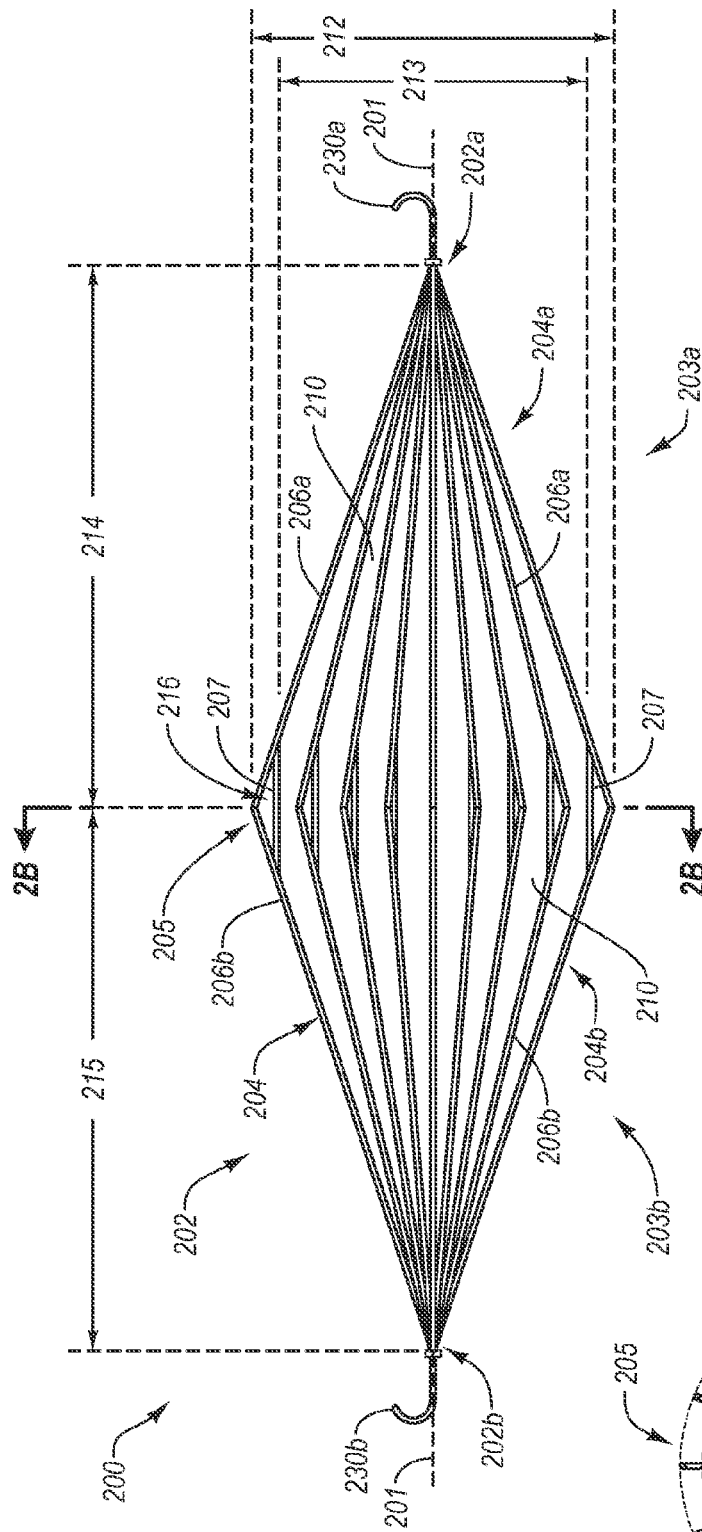


Fig. 2A

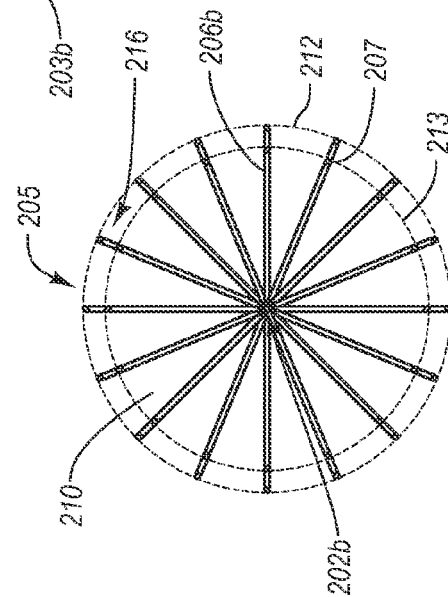


Fig. 2B

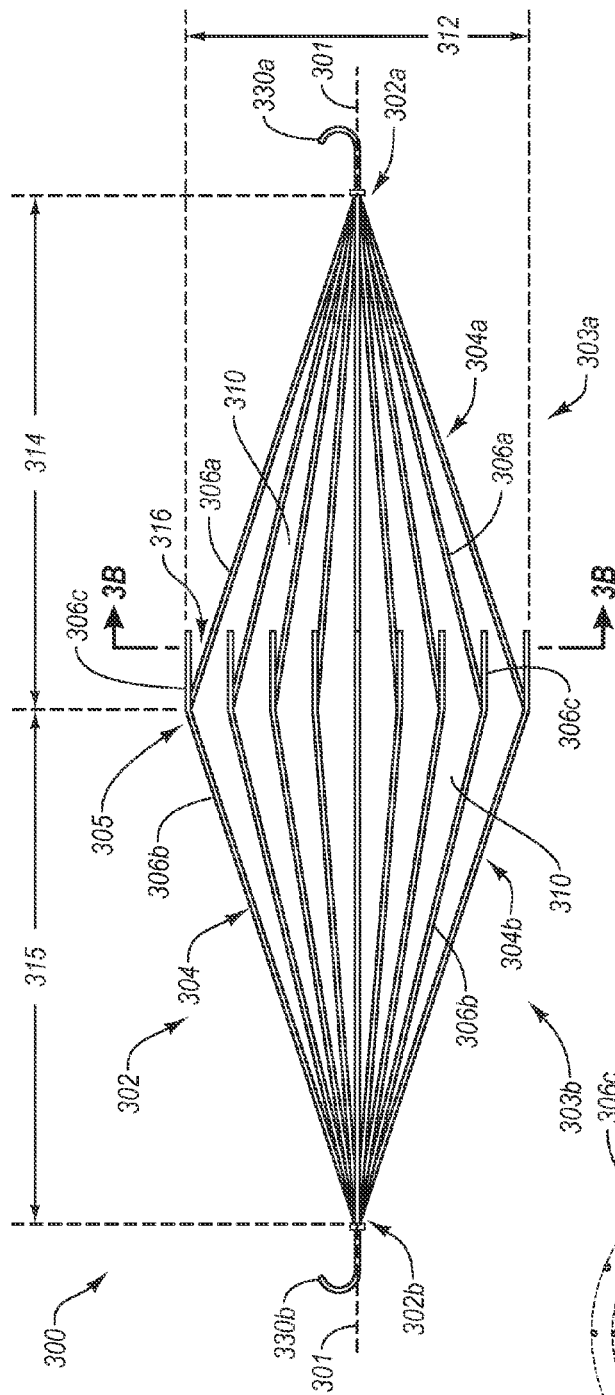


Fig. 3A

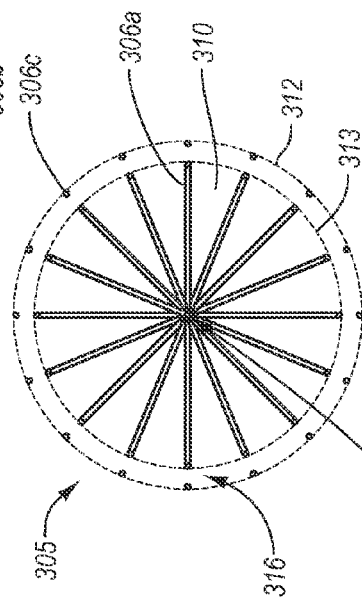


Fig. 3B

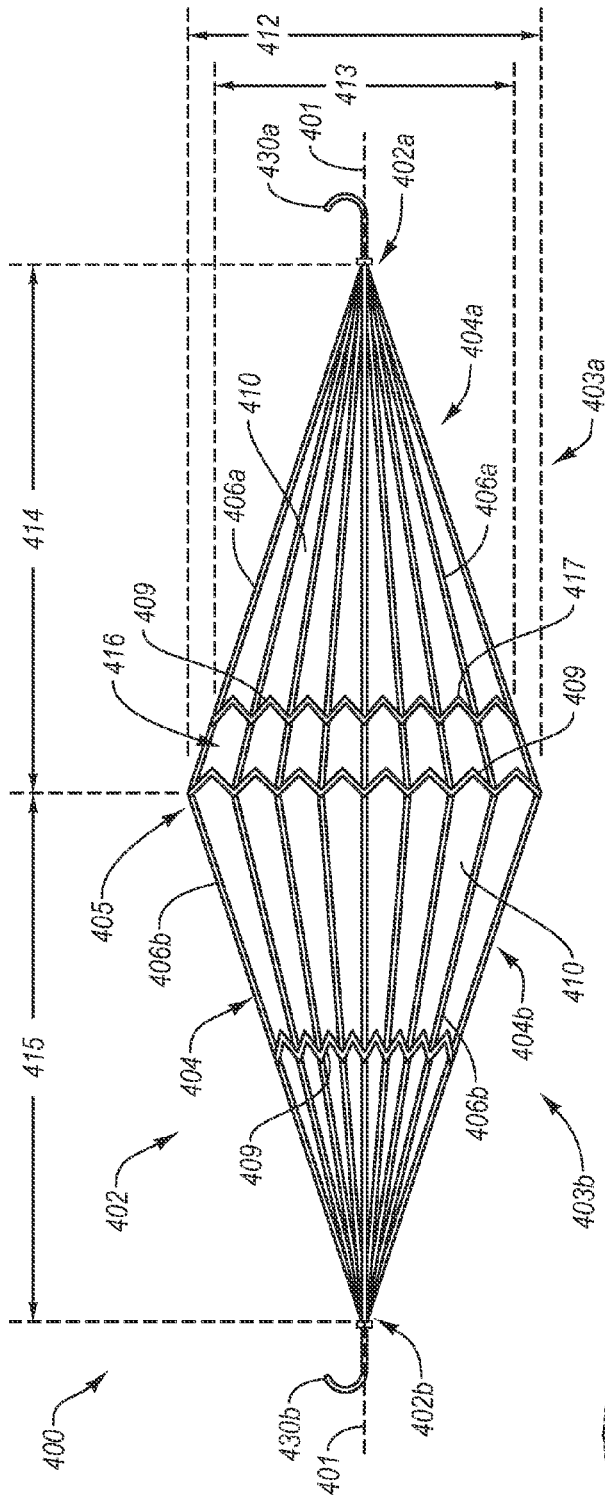


Fig. 4A

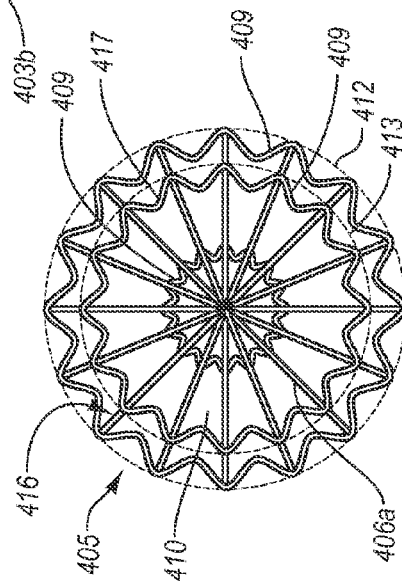


Fig. 4B

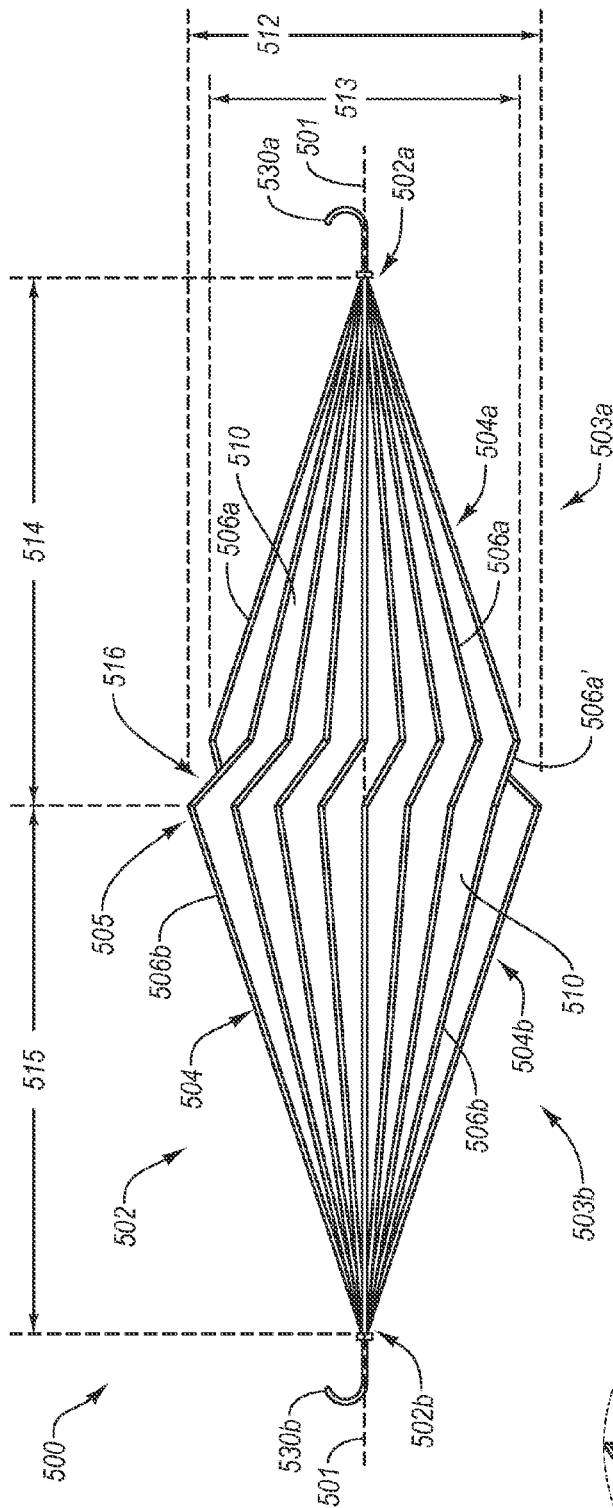


Fig. 5A

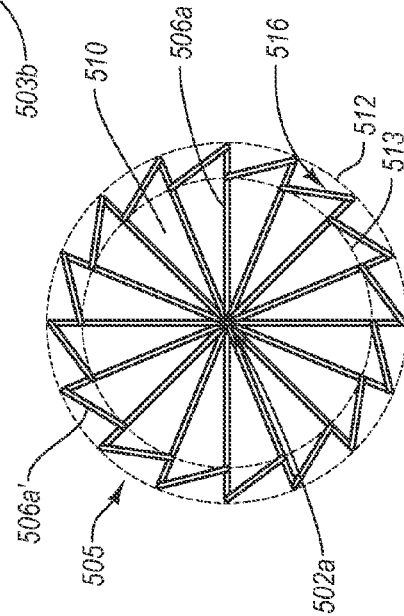
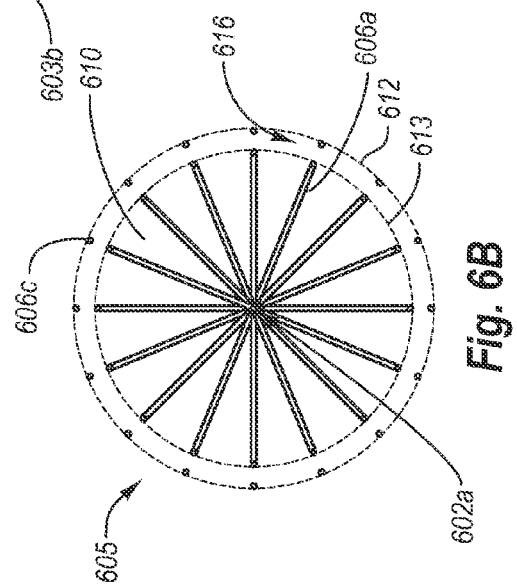
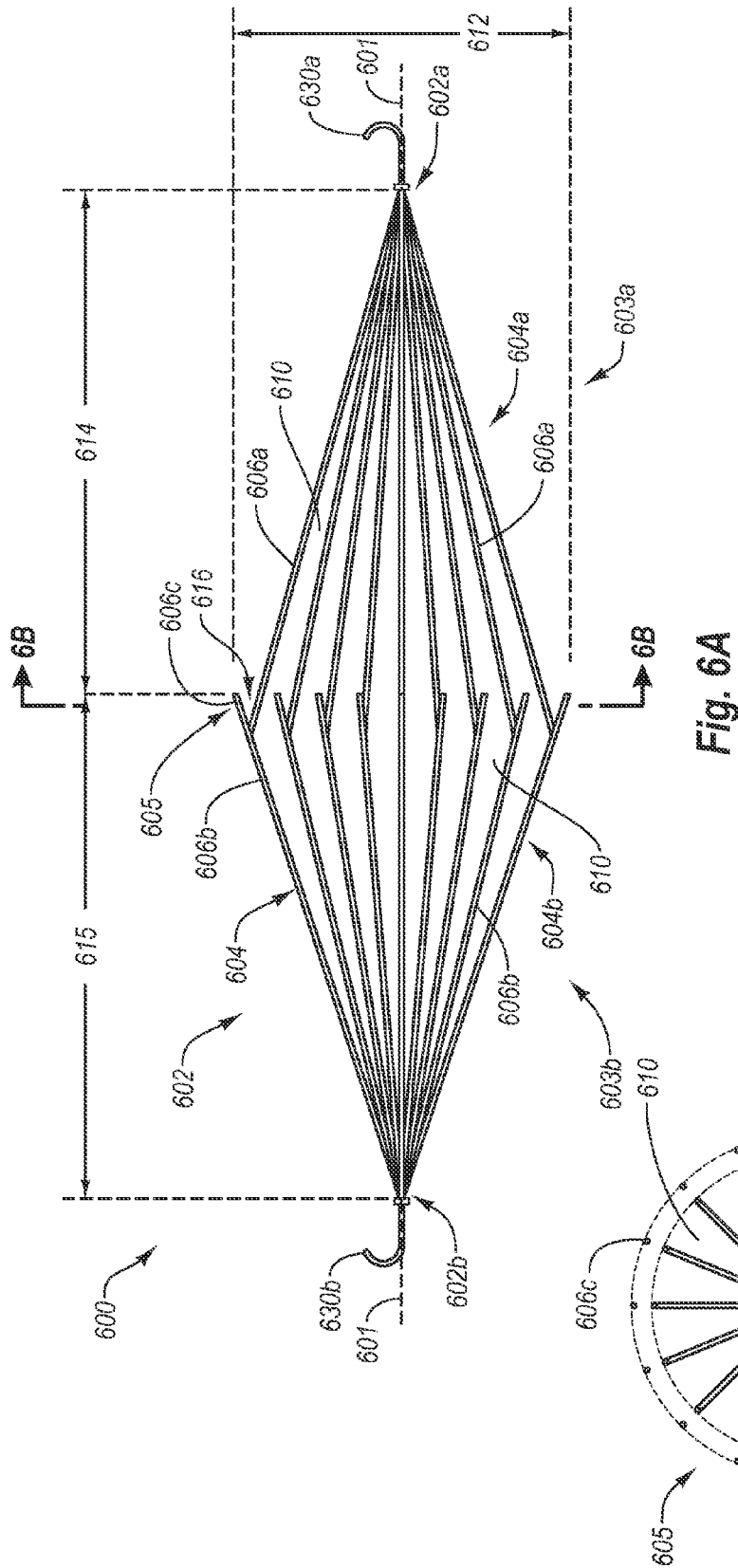


Fig. 5B



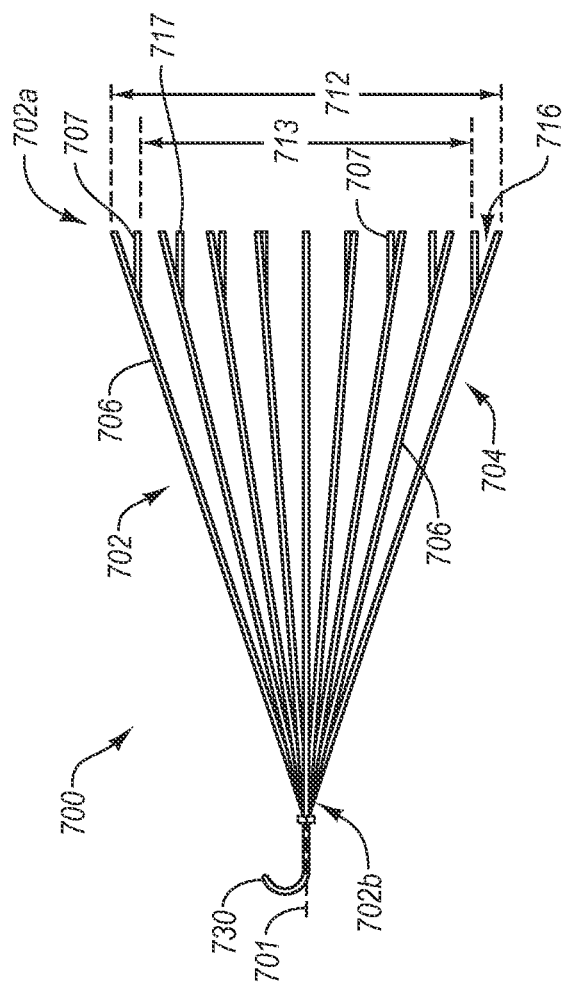


Fig. 7A

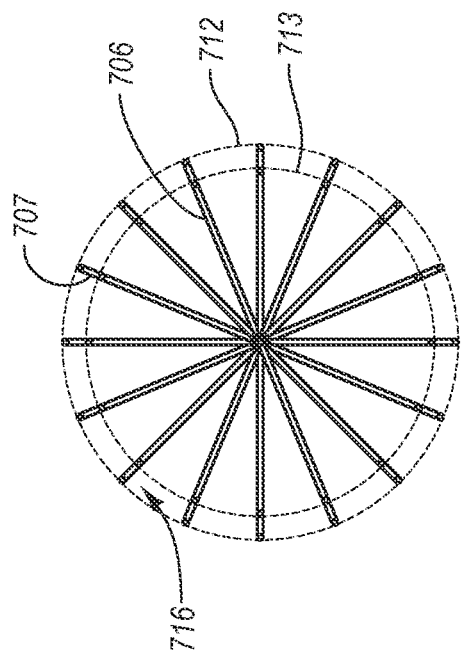


Fig. 7B

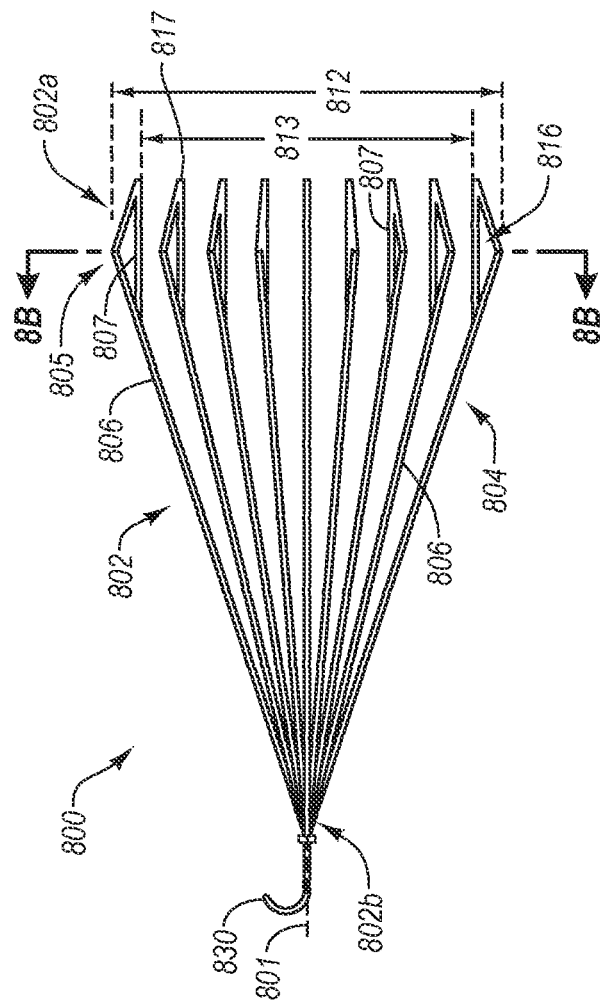
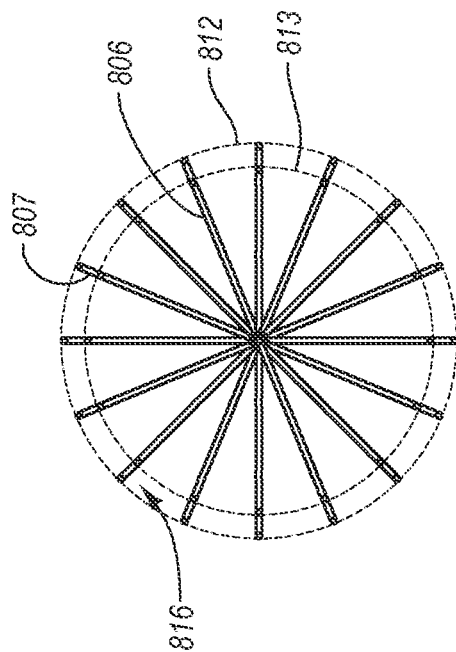


Fig. 8A



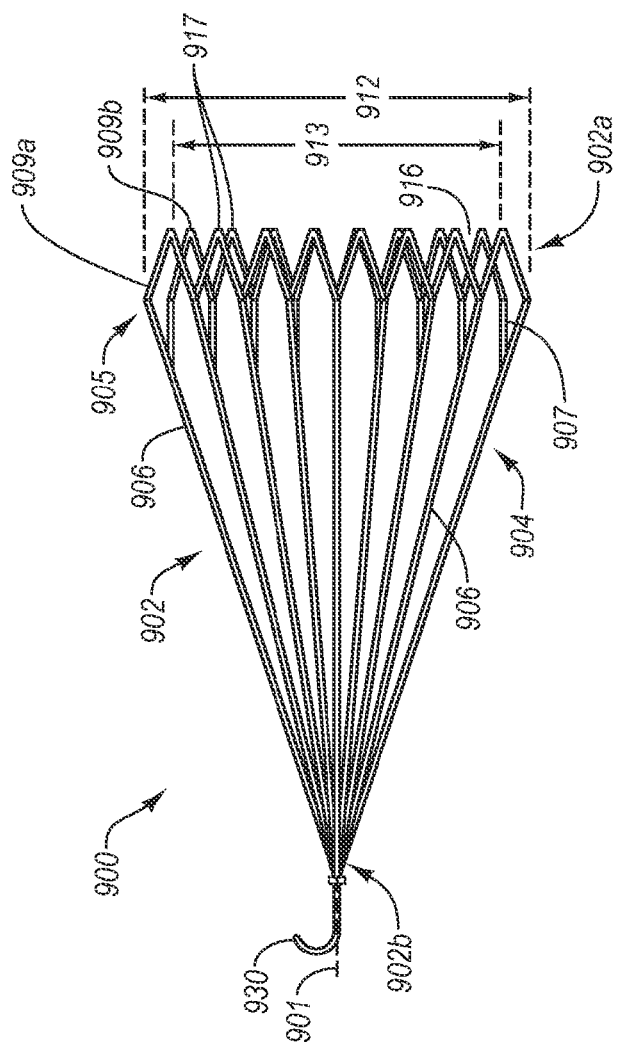


Fig. 9A

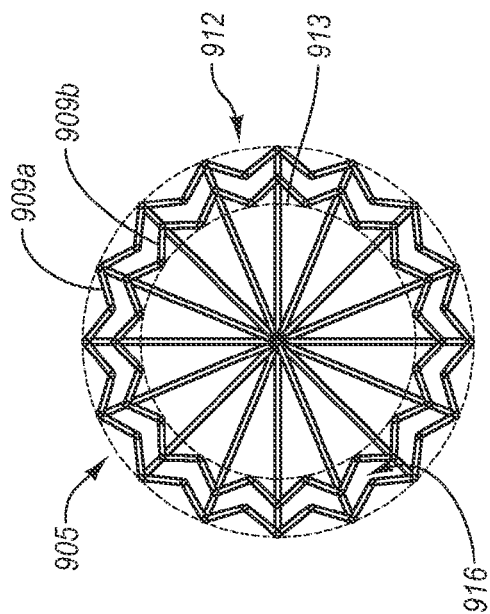


Fig. 9B

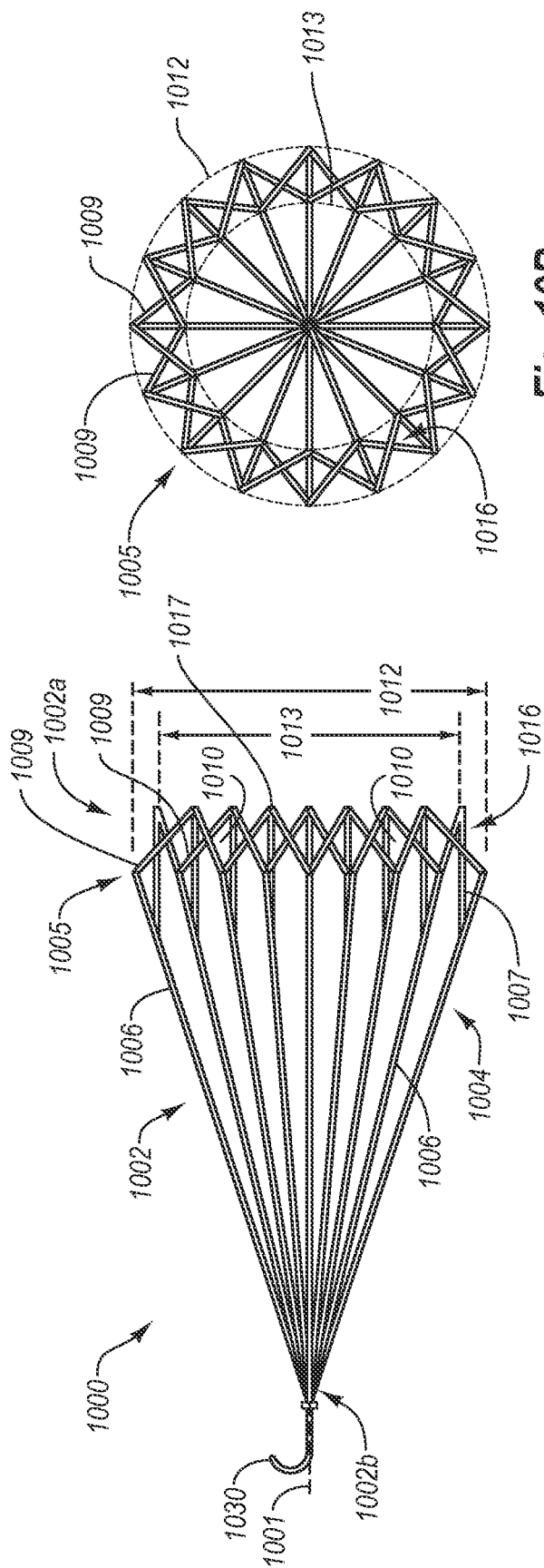
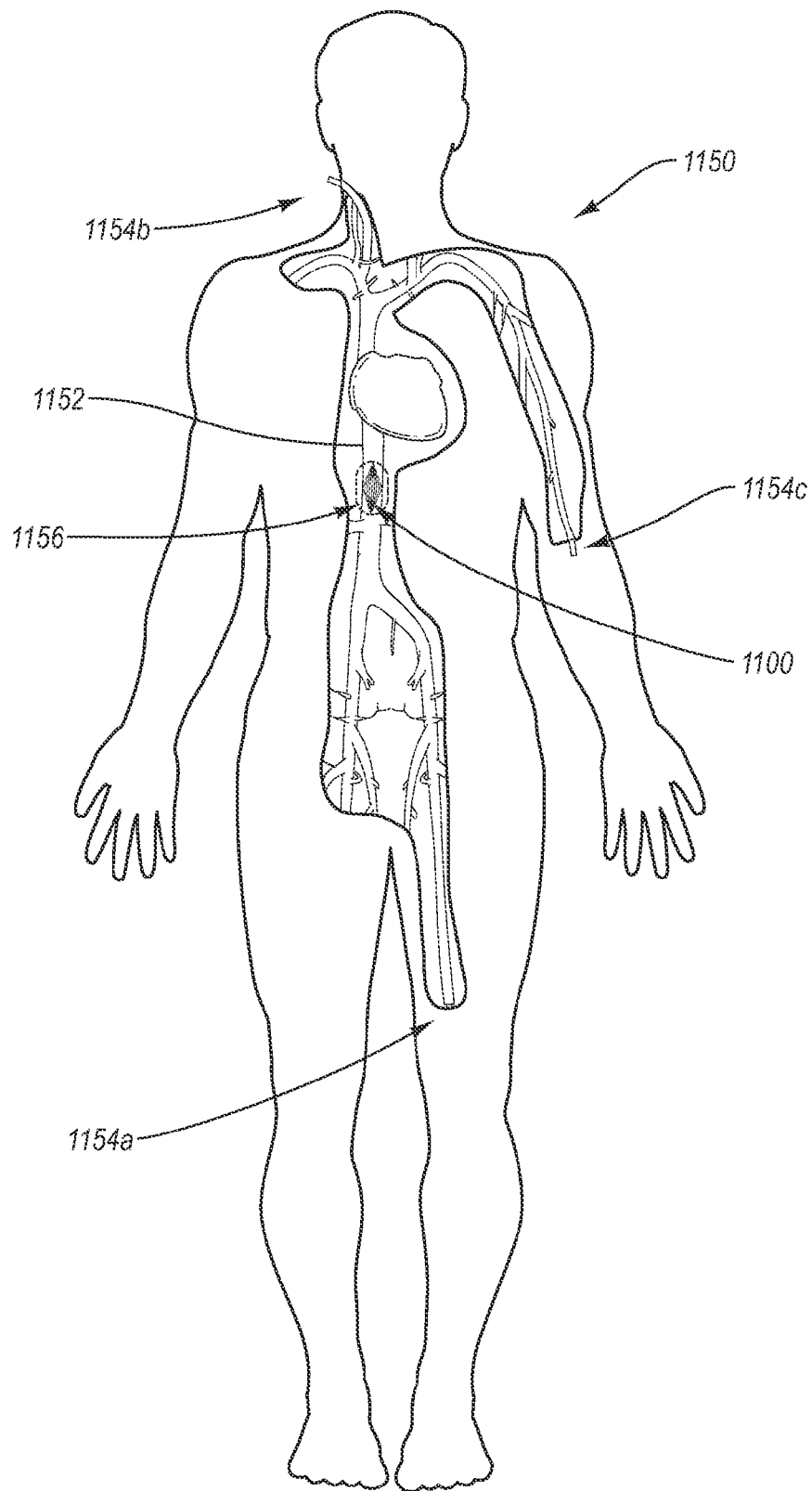


Fig. 10A

Fig. 10B

**Fig. 11**

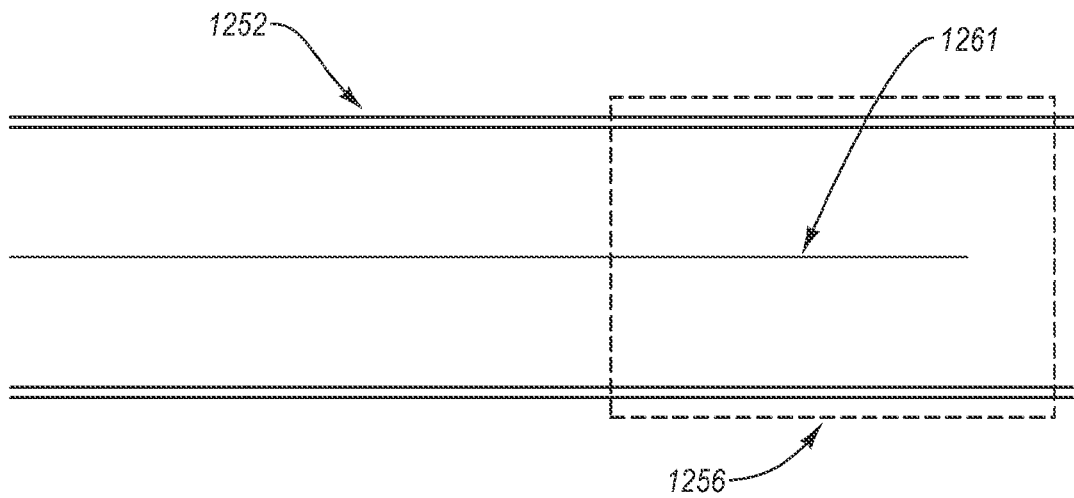


Fig. 12A

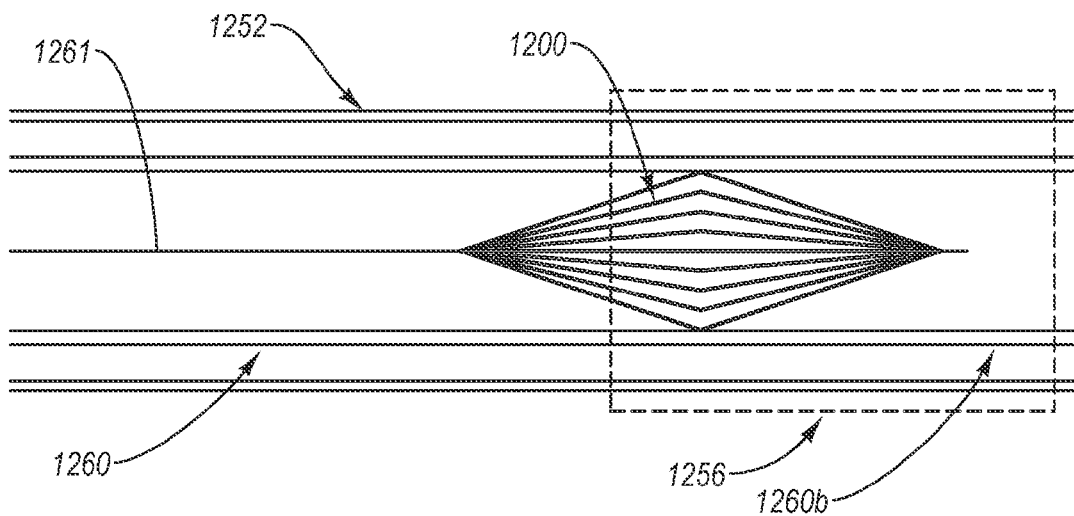


Fig. 12B

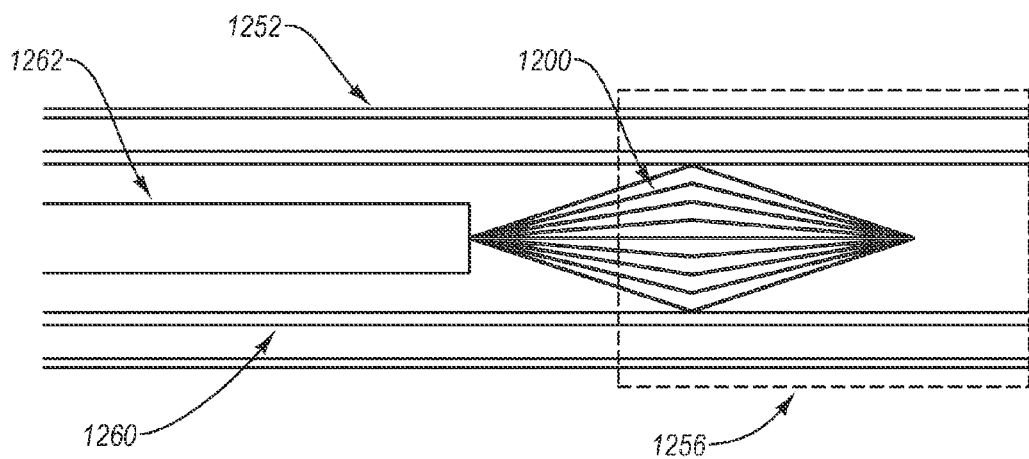


Fig. 12C

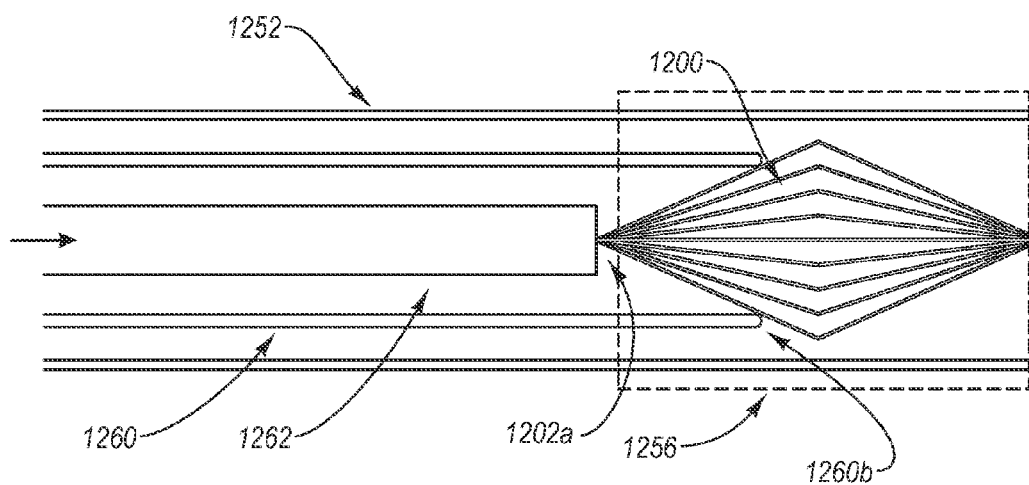


Fig. 12D

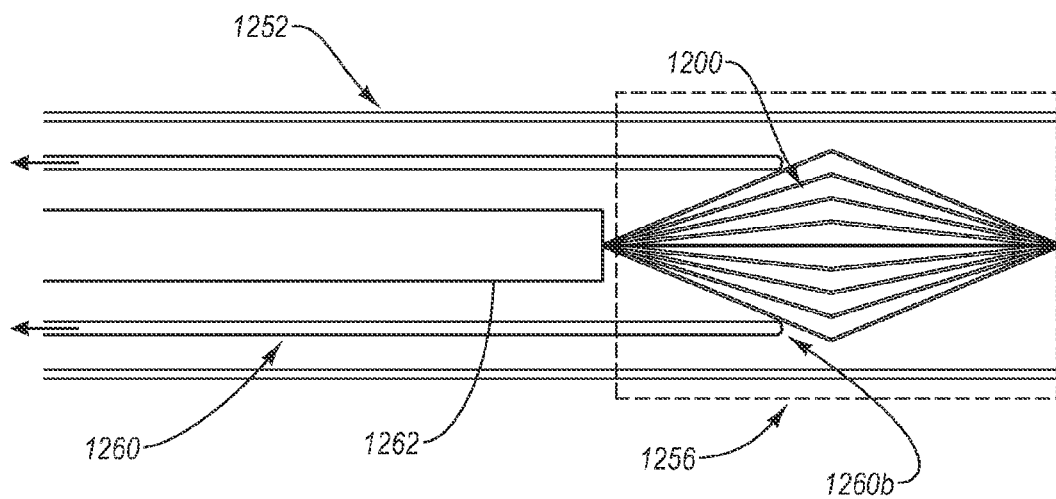


Fig. 12D'

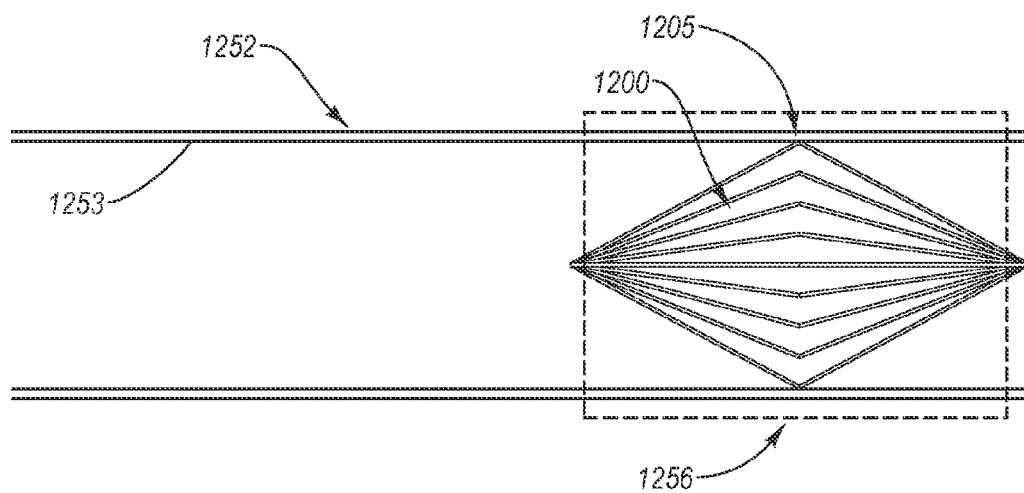


Fig. 12E

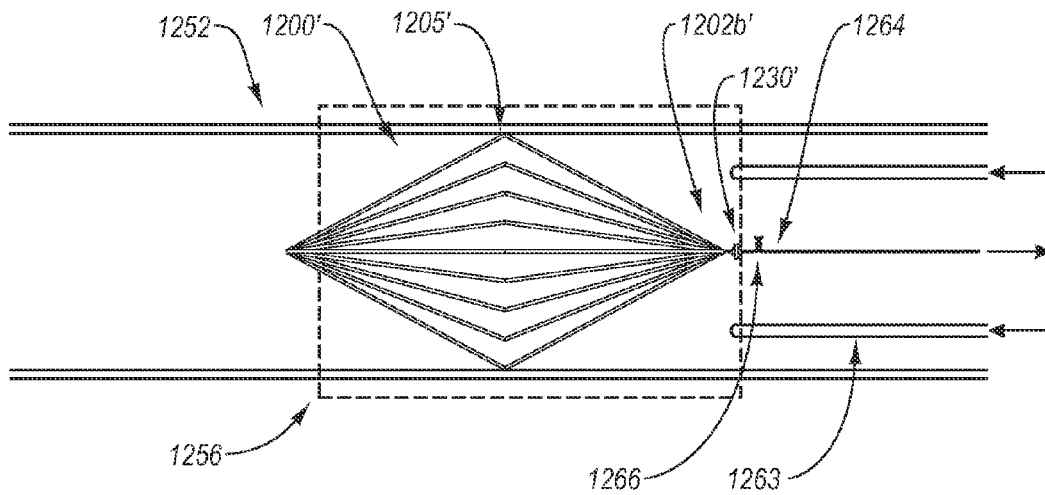


Fig. 12F

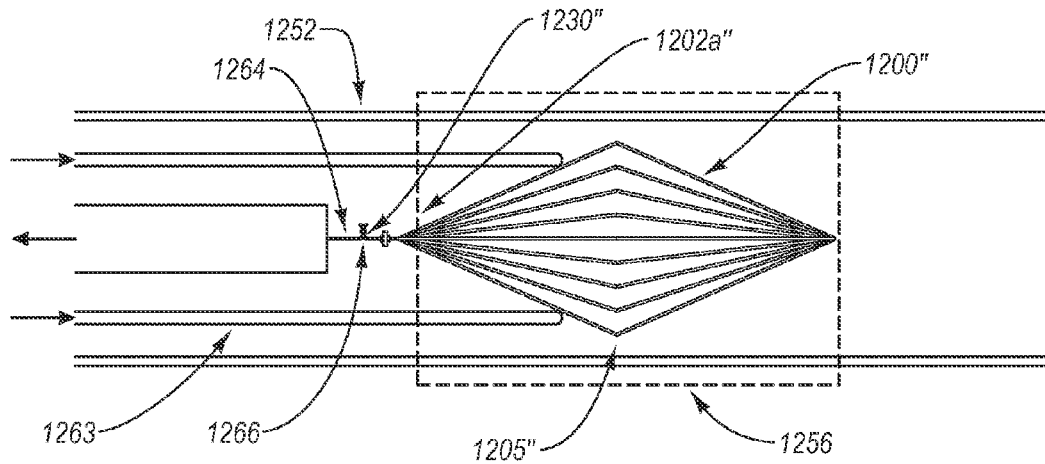


Fig. 12F'

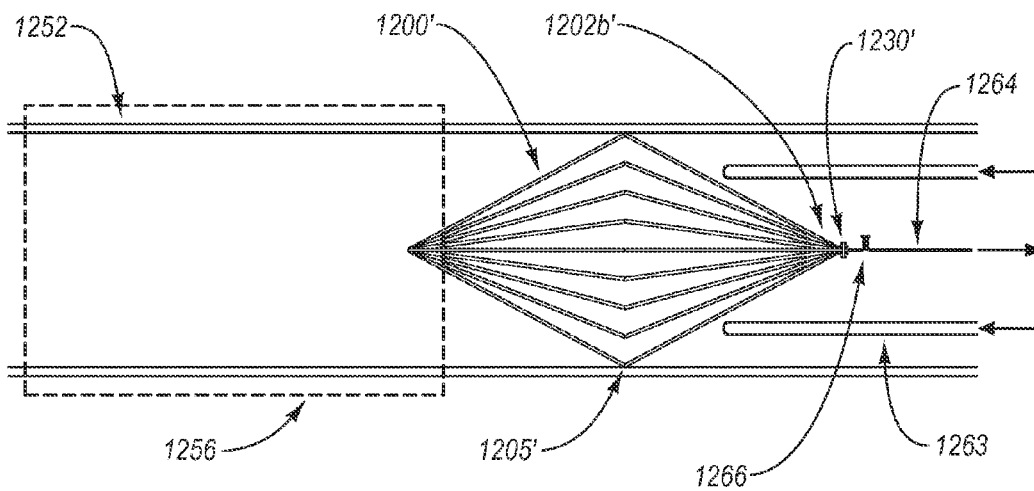


Fig. 12G

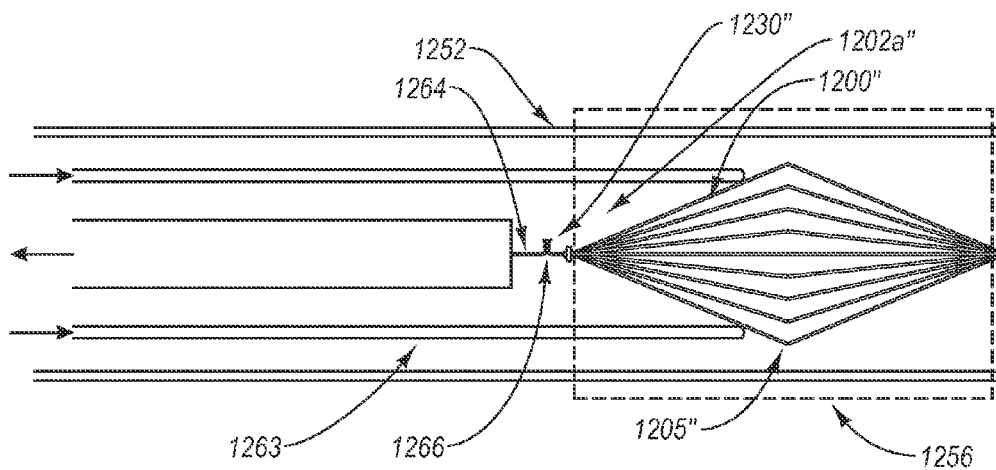


Fig. 12G'

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IMPLANTABLE LUMEN FILTER WITH ENHANCED DURABILITY

CROSS-REFERENCE TO RELATED APPLICATIONS

This Patent Application is a U.S. National Stage of International Application No. PCT/US2009/068287, filed Dec. 16, 2009, which claims the benefit of and priority to U.S. Provisional Patent Application having Ser. No. 61/138,470, filed on Dec. 17, 2008, the disclosures of which are incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates generally to medical devices. More particularly the present invention relates to an implantable lumen filter with enhanced durability.

BACKGROUND OF THE INVENTION

Vein thrombosis is a medical condition wherein a blood clot, or thrombus, has formed inside a vein. Such a clot often develops in the calves, legs, or lower abdomen, but can also affect other veins in the body. The clot may partially or completely block blood flow, and may break off and travel through the bloodstream. Commonly, the clot is caused by a pooling of blood in the vein, often when an individual is bed-ridden for an abnormally long duration of time, for example, when resting following surgery or suffering from a debilitating illness, such as a heart attack or traumatic injury. However, there are many other situations that cause the formation of a blood clot.

Vein thrombosis is a serious problem because of the danger that the clot may break off and travel through the bloodstream to the lungs, causing a pulmonary embolism. A pulmonary embolism is an obstruction of the pulmonary artery or one of its branches by a blood clot or other foreign substance. A pulmonary embolism can be caused by a blood clot which migrated into the pulmonary artery or one of its branches.

This is similar to a blockage of the blood supply to the lungs that causes severe hypoxia and cardiac failure, and frequently results in death. For many patients, anti-coagulant drug therapies may be sufficient to dissipate the clots. For example, patients may be treated with anticoagulants such as heparin and with thrombolytic agents such as streptokinase.

Unfortunately, some patients may not respond to such drug therapy or may not tolerate such therapy. Also, there may be other reasons why an anticoagulant is not desirable. For example, patients may have an acute sensitivity to heparin or may suffer from prolonged internal and/or external bleeding as a result of such drug therapies. Also, such drug therapies simply may be ineffective in preventing recurrent pulmonary emboli. In such circumstances, surgical procedures are required to prevent pulmonary emboli. Methods for prevention of primary or recurrent pulmonary emboli when anticoagulation therapies are ineffective are well-defined in the prior art. The current standard of therapy for prevention of pulmonary emboli in patients who are classified high-risk or are unable to be anticoagulated is percutaneous insertion and placement of an inferior vena cava filter device.

Vena cava filters are devices which are implanted in the inferior vena cava, providing a mechanical barrier to undesirable particulates. The filters may be used to filter peripheral venous blood clots and other particulates, which if remaining in the blood stream can migrate into the pulmonary artery or one of its branches and cause harm.

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Vena cava filters can filter the blood stream by catching and collecting particulates within the blood stream. However, the basket-like shape of the filter may cause the particulates to congregate or collect near the center of the blood stream. This can result in an occlusion within the inferior vena cava, particularly as the amount of particulates builds within the vena cava filter. Not only can this reduce the usable lifespan of the filter, but it can also potentially cause serious harm to the patient.

Therefore, an implantable lumen filter with an enhanced durability and methods for filtering a body lumen may be useful.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific configurations thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical configurations of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings.

FIGS. 1A-B illustrate an example implantable lumen filter.

FIGS. 2A-B illustrate another example implantable lumen filter.

FIGS. 3A-B illustrate a further example implantable lumen filter.

FIGS. 4A-B illustrate a still further example implantable lumen filter.

FIGS. 5A-B illustrate a yet further example implantable lumen filter.

FIGS. 6A-B illustrate another example implantable lumen filter.

FIGS. 7A-B illustrate a further example implantable lumen filter.

FIGS. 8A-B illustrate a still further example implantable lumen filter.

FIGS. 9A-B illustrate a yet further example implantable lumen filter.

FIGS. 10A-B illustrate another example implantable lumen filter.

FIG. 11 illustrates an exemplary subject for an implantable lumen filter.

FIGS. 12A-12G' illustrate various steps in the deployment of an example implantable lumen filter.

It should be noted that the figures are not drawn to scale and that elements of similar structures or functions are generally represented by like reference numerals for illustrative purposes throughout the figures. It also should be noted that the figures are only intended to facilitate the description of example configurations of the present invention.

DETAILED DESCRIPTION

The configurations described herein extend generally to an implantable lumen filter with enhanced durability and methods for filtering a body lumen. By way of example only, a body lumen may include a blood vessel. Filtering of the body lumen may be performed by implantable lumen filters. For instance, configurations of implantable lumen filters (e.g. including vena cava and/or other lumen filters), are described. Components of implantable filters also are described.

Some implantable lumen filters may be designed to capture, inhibit, and/or lyse particulates of a particular size within the lumen. Many implantable lumen filters may be generally tapered from a distal end toward a proximal end. For example, implantable lumen filters may be generally cone shaped. As a result of their shape, many implantable lumen filters may direct particulates towards and capture the particulates within a central portion of the lumen. As particulates collect within the filter near the center of the lumen, flow within the lumen, such as blood flow, is disrupted and/or reduced. This can lead to an occlusion thereby reducing the usable lifespan of the filter and potentially causing harm to a patient.

Example implantable lumen filters described herein may be configured to direct particulates within a lumen radially outwardly and/or to collect particulates proximate an inner wall of the lumen. By so doing, the example implantable lumen filters described herein can reduce or eliminate obstructions within the central portion of the lumen. As a result, these implantable lumen filters can have longer usable lifespans and enhanced safety characteristics.

The example implantable lumen filters described herein may be manufactured from any suitable material. For example, an implantable lumen filter may be at least partially formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium alloys and/or alloys thereof, other materials, and/or combinations thereof. These materials may include at least one beneficial agent incorporated into the material and/or coated over at least a portion of the material.

The beneficial agents may be applied to implantable lumen filters that have been coated with a polymeric compound. Incorporation of the compound or drug into the polymeric coating of the implantable lumen filter can be carried out by dipping the polymer-coated implantable lumen filter into a solution containing the compound or drug for a sufficient period of time (such as, for example, five minutes) and then drying the coated implantable lumen filter, such as by way of air drying for a sufficient period of time (such as, for example, 30 minutes). The polymer-coated implantable lumen filter containing the beneficial agent may then be delivered to a body vessel.

The pharmacologic agents that can be effective in preventing restenosis can be classified into the categories of anti-proliferative agents, anti-platelet agents, anti-inflammatory agents, anti-thrombotic agents, and thrombolytic agents. Anti-proliferative agents may include, for example, crystalline rapamycin. These classes can be further sub-divided. For example, anti-proliferative agents can be anti-mitotic. Anti-mitotic agents inhibit or affect cell division, whereby processes normally involved in cell division do not take place. One sub-class of anti-mitotic agents includes vinca alkaloids. Representative examples of vinca alkaloids include, but are not limited to, vincristine, paclitaxel, etoposide, nocodazole, indirubin, and anthracycline derivatives, such as, for example, daunorubicin, daunomycin, and plicamycin. Other sub-classes of anti-mitotic agents include anti-mitotic alkylating agents, such as, for example, tauromustine, bofomustine, and fotemustine, and anti-mitotic metabolites, such as, for example, methotrexate, fluorouracil, 5-bromodeoxyuridine, 6-azacytidine, and cytarabine. Anti-mitotic alkylating agents affect cell division by covalently modifying DNA, RNA, or proteins, thereby inhibiting DNA replication, RNA transcription, RNA translation, protein synthesis, or combinations of the foregoing.

Anti-platelet agents are therapeutic entities that act by (1) inhibiting adhesion of platelets to a surface, typically a throm-

bogenic surface, (2) inhibiting aggregation of platelets, (3) inhibiting activation of platelets, or (4) combinations of the foregoing. Activation of platelets is a process whereby platelets are converted from a quiescent, resting state to one in which platelets undergo a number of morphologic changes induced by contact with a thrombogenic surface. These changes include changes in the shape of the platelets, accompanied by the formation of pseudopods, binding to membrane receptors, and secretion of small molecules and proteins, such as, for example, ADP and platelet factor 4. Anti-platelet agents that act as inhibitors of adhesion of platelets include, but are not limited to, eptifibatide, tirofiban, RGD (Arg-Gly-Asp)-based peptides that inhibit binding to gpIIb/IIIa or $\alpha v \beta 3$, antibodies that block binding to gpIIa/IIIb or $\alpha v \beta 3$, anti-P-selectin antibodies, anti-E-selectin antibodies, compounds that block P-selectin or E-selectin binding to their respective ligands, saratin, and anti-von Willebrand factor antibodies. Agents that inhibit ADP-mediated platelet aggregation include, but are not limited to, disagegrenin and cilostazol.

Anti-inflammatory agents can also be used. Examples of these include, but are not limited to, prednisone, dexamethasone, hydrocortisone, estradiol, fluticasone, clobetasol, and non-steroidal anti-inflammatories, such as, for example, acetaminophen, ibuprofen, naproxen, and sulindac. Other examples of these agents include those that inhibit binding of cytokines or chemokines to the cognate receptors to inhibit pro-inflammatory signals transduced by the cytokines or the chemokines. Representative examples of these agents include, but are not limited to, anti-IL1, anti-IL2, anti-IL3, anti-IL4, anti-IL8, anti-IL15, anti-IL18, anti-GM-CSF, and anti-TNF antibodies.

Anti-thrombotic agents include chemical and biological entities that can intervene at any stage in the coagulation pathway. Examples of specific entities include, but are not limited to, small molecules that inhibit the activity of factor Xa. In addition, heparinoid-type agents that can inhibit both FXa and thrombin, either directly or indirectly, such as, for example, heparin, heparin sulfate, low molecular weight heparins, such as, for example, the compound having the trademark Clivarin®, and synthetic oligosaccharides, such as, for example, the compound having the trademark Arixtra®. Also included are direct thrombin inhibitors, such as, for example, melagatran, ximelagatran, argatroban, inogatran, and peptidomimetics of binding site of the Phe-Pro-Arg fibrinogen substrate for thrombin. Another class of anti-thrombotic agents that can be delivered is factor VII/VIIa inhibitors, such as, for example, anti-factor VII/VIIa antibodies, rNAPc2, and tissue factor pathway inhibitor (TFPI).

Thrombolytic agents, which may be defined as agents that help degrade thrombi (clots), can also be used as adjunctive agents, because the action of lysing a clot helps to disperse platelets trapped within the fibrin matrix of a thrombus. Representative examples of thrombolytic agents include, but are not limited to, urokinase or recombinant urokinase, pro-urokinase or recombinant pro-urokinase, tissue plasminogen activator or its recombinant form, and streptokinase.

One or more immunosuppressant agents may be used. Immunosuppressant agents may include, but are not limited to, IMURAN® azathioprine sodium, brequinar sodium, SPANIDIN® gusperimus trihydrochloride (also known as deoxyspergualin), mizoribine (also known as bredinin), CELLCEPT® mycophenolate mofetil, NEORAL® Cyclosporin A (also marketed as different formulation of Cyclosporin A under the trademark SANDIMMUNE®), PROGRAM tacrolimus (also known as FK-506), sirolimus and RAPAMUNE®, leflunomide (also known as HWA-486), glucocorticoids, such as prednisolone and its derivatives,

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antibody therapies such as orthoclone (OKT3) and Zenapax®, and antithymocyte globulins, such as thymoglobulins. In addition, a crystalline rapamycin analog, A-94507, SDZ RAD (a.k.a. Everolimus), and/or other immunosuppressants.

FIGS. 1A-B illustrate an example implantable lumen filter 100 according to some configurations. In FIG. 1A, the implantable lumen filter 100 is shown in flattened form for ease of discussion. FIG. 1B illustrates an end view of the implantable lumen filter 100 of FIG. 1A. The implantable lumen filter 100 may include a body 102 having a proximal end 102a and a distal end 102b. The proximal end 102a may be the end of the body 102 that is typically opposite to the end typically advanced first into a body lumen to deploy the implantable lumen filter 100. In other configurations, the proximal end 102a may be the end of the body 102 that is first disposed within a body lumen. The body 102 may be transitionable from a compressed state toward an expanded state and is shown in FIGS. 1A-B in the expanded state. The implantable lumen filter 100 may also include one or more retrieval portions 130a, 130b coupled to the body 102 for retrieving the body 102 from a lumen.

The body 102 of the example implantable lumen filter 100 may include an outer surface 104 defined by a plurality of outer struts 106. The body 102 may include a proximal portion 103a and a distal portion 103b. The proximal portion 103a of the body 102 may include a proximal outer surface 104a defined by a plurality of proximal outer struts 106a. In the illustrated configuration, the proximal outer struts 106a each extend from the proximal end 102a toward an apex 105. At least some of the plurality of struts 106a can extend generally in alignment with a longitudinal axis 101. As used herein, the term “extend generally in alignment with a longitudinal axis” means to extend generally along a plane that contains the longitudinal axis. The proximal outer surface 104a may have a generally tapered shape from the apex 105 to the proximal end 102a. As used herein, a generally tapered shape may include a line and/or curve tapered toward and rotated about a longitudinal axis 101, a generally right circular conical outer surface, a generally oblique conic outer surface, and/or other shapes that generally taper toward the one end.

The distal portion 103b may include a distal outer surface 104b defined by a plurality of distal outer struts 106b. In the illustrated configuration, the distal outer struts 106b extend longitudinally from the distal end 102b toward the apex 105 and can be generally in alignment with the longitudinal axis 101. The distal outer surface 104b may have a generally tapered shape from the apex 105 to the distal end 102b.

The implantable lumen filter 100 may be generally narrower near the proximal end 102a and distal end 102b with the apex 105 of the body 102 being a generally wider portion of the implantable lumen filter 100. The apex 105 may operate to anchor the implantable lumen filter 100 against the inner wall of a lumen. For example, in its expanded/deployed state, the body 102 may have an outer dimension 112 at or near the apex 105 which is similar to the inner dimension of the lumen wall.

The apex 105 may be configured to engage an inner surface of the body lumen. The surface area and/or other features of the apex 105 may be determined to facilitate engagement of the inner wall of the body lumen. The apex 105 may also impart a radial force to an inner surface of a body lumen. The apex 105 may impart a radial force sufficient to anchor the implantable lumen filter 100 without piercing an inner surface of the body lumen.

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The apex 105 may be dimensioned and configured to generally align the implantable lumen filter 100 within a body lumen. The apex 105 may facilitate alignment within the body lumen by controlling the surface area of the implantable lumen filter 100 to be in contact with the body lumen, by increasing the radial force applied by the implantable lumen filter 100, by other features, and/or combinations of the same.

The apex 105, in the illustrated configuration, may include a generally angular shape in the outer surface 104. In further configurations, however, the apex 105 may be less angular and more rounded or planar. Near the apex 105, the outer surface 104 can vary more in its shape than the remainder of the outer surface 104, such as the proximal outer surface 104a or the distal outer surface 104b, which may include a more constant surface shape that tapers from the apex 105 to the proximal end 102a or the distal end 102b.

The body 102 may also include a first longitudinal dimension 114 and a second longitudinal dimension 115. The first longitudinal dimension 114 may extend from the proximal end 102a to the apex 105 generally parallel with the longitudinal axis 101 and represent the longitudinal length of the proximal portion 103a. The second longitudinal dimension 115 may extend from the distal end 102b to the apex 105 generally parallel with the longitudinal axis 101 and represent the longitudinal length of the distal portion 103b. The first longitudinal dimension 114 and second longitudinal dimension 115 may be substantially equal or may differ with the first longitudinal dimension 114 being longer or shorter than the second longitudinal dimension 115.

The outer struts 106 of the body 102 may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the outer struts 106. In configurations where the body 102 is not defined by outer struts 106, the structure defining the body 102 may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body 102.

The outer struts 106 may be welded and/or otherwise connected together to form the body 102. For example, the body 102 may be formed by welding or otherwise connecting the proximal outer struts 106a and distal outer struts 106b together. In particular, the distal ends of the proximal outer struts 106a can be connected to the corresponding proximal ends of the distal outer struts 106b to form the body 102. In addition, the connection between the proximal outer struts 106a and distal outer struts 106b may at least partially define the apex 105 in the outer surface 104. In a further configuration, one or more outer struts 106 may extend as single pieces from the proximal end 102a to the distal end 102b and include bends and/or other features to define the apex 105.

The proximal outer struts 106a may also be welded or otherwise connected together at the proximal end 102a, while the distal outer struts 106b may be welded or otherwise connected together at the distal end 102b. In other configurations, the outer struts 106 may be formed by removing material from the body 102 using, for example, laser cutting, etching, machining, grinding, and/or other suitable material removing procedures.

The outer struts 106 may form a plurality of apertures 110 in the body 102. In the configuration illustrated in FIGS. 1A-B, the example outer struts 106 form generally elongated V-shaped apertures extending between adjacent outer struts

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106 from the proximal end **102a** and distal end **102b** to the apex **105**, the apertures **110** defining wider openings near the apex **105** and narrower openings near the proximal and distal ends **102a**, **102b**, respectively. The number of outer struts **106** can be selectively determined to produce a desired spacing between adjacent outer struts **106** and a corresponding aperture **110** size and shape. In further configurations, the outer struts **106** may form apertures **110** having other shapes, such as diamond shapes, triangular shapes, chevron shapes, polygonal shapes, and/or other suitable shapes. In some configurations, the outer struts **106** may form apertures **110** that are generally the same shape. In other configurations, the outer struts **106** may form apertures **110** that are different shapes and/or varying shapes.

The apertures **110** may be spread across various locations of the body **102**. The size and/or number of apertures **110** may vary and may be selected to inhibit passage of and/or to lyse particulates of a selected size while allowing blood components smaller than the selected size to pass through said apertures.

The apertures **110** can be selectively configured to allow a particulate of a particular size to pass through the body **102**. For example, in the example implantable lumen filter **100** of FIGS. 1A-B, the outer struts **106** can be selectively spaced as desired to define the size and/or shape of the apertures **110** so as to only allow passage of particulates smaller than a selected size. The number of outer struts **106** included in the implantable lumen filter **100** can be increased or decreased as desired to increase or decrease the size and/or shape of the apertures **110**.

In further configurations, the size and/or shape of apertures **110** located within the proximal portion **103a** may differ from the size and/or shape of apertures **110** located within the distal portion **103b**. In addition, the positions of apertures **110** may vary from the proximal portion **103a** to the distal portion **103b** as desired. Furthermore, the number of proximal outer struts **106a** of the proximal portion **103a** may be larger or smaller than the number of distal outer struts **106b** of the distal portion **103b**.

The proximal portion **103a** and distal portion **103b** may be generally symmetrical about a plane defined by the apex **105**. For example, the proximal and distal portions **103a**, **103b** can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends **102a**, **102b**, respectively, and with the wider base portion of the cone being located at or near the apex **105**. In further configurations, the size and/or shape of the proximal portion **103a** can differ from the size and/or shape of the distal portion **103b**.

The implantable lumen filter **100** can be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body **102** of the implantable lumen filter **100** may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension **112** of the body **102** and/or inner surface of a lumen wall.

In one example configuration, the implantable lumen filter **100** can be deployed within a body lumen such that the proximal portion **103a** is located on the upstream side of the implantable lumen filter **100**. The proximal portion **103a** can be configured to direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface **104a** towards the outer dimension **112** of the body **102**. For instance, when a particulate collides with the proximal outer surface **104a**, the proximal outer struts **106a** can deflect the particulate towards the lumen wall. In addition, particulates may travel along the

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longitudinally extending proximal outer struts **106a** until they either reach an aperture **110** in the body **102** large enough to pass through the body, become lysed into smaller particulates small enough to pass through the body **102**, become collected between the proximal outer surface **104a** and a lumen wall, become collected by one or more outer struts **106a**, and/or combinations of the same.

Accordingly, the example implantable lumen filter **100** can direct particulates towards and cause particulates to be collected near the outer dimension **112** of the body **102** and/or the inner surface of the lumen wall. As a result, some aspects of the example implantable lumen filter **100** can limit or prevent blockage of the central portion of a lumen, thereby maintaining flow within the lumen for a longer period of time. Thus, the example implantable lumen filter **100** disclosed in FIGS. 1A-B can enhance the lifespan, durability, and safety of the implantable lumen filter **100**.

In a further embodiment, the implantable lumen filter **100** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **100** can be deployed with either the distal end **102b** or the proximal end **102a** positioned on the upstream side of the implantable lumen filter **100** within the lumen.

Once a particulate is collected by the implantable lumen filter **100**, one or more beneficial agents can be introduced into the lumen flow in order to further break down and/or lyse the particulate. For example, the beneficial agent(s) can break the particulate down into smaller particulates that are able to pass through the apertures **110**. As a result, very few or no particulates may remain collected upon the implantable lumen filter **100** when it is retrieved from the lumen.

Alternatively, particulates may remain collected by the implantable lumen filter **100** until the implantable lumen filter **100** is removed from the lumen. In particular, the implantable lumen filter **100** may be removed in such a way so as to effectively collect any particulates released into the flow of the lumen when the implantable lumen filter **100** disengages the lumen wall. For example, a retrieval apparatus (e.g., **1263**, FIG. 12F) used to retrieve the implantable lumen filter **100** from a lumen may include a particulate collector that extends from the retrieval apparatus and abuts a lumen wall downstream from the deployed position of the implantable lumen filter **100**. If particulates are released as the implantable lumen filter **100** is retrieved from the lumen, the particulates can be collected within the particulate collector and then removed from the lumen along with the retrieval apparatus.

The implantable lumen filter **100** may incorporate at least one component of the implantable lumen filters **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. 2-12, respectively. The following non-limiting list of examples indicates the interchangeability of at least some of the components of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described herein. For instance, the implantable lumen filter **100** can include one or more inner struts (e.g., **207**, **707**, **807**, **907**, and **1007**, as shown in FIGS. 2 and 7-10, respectively) in addition to the plurality of outer struts **106**. In another example, the implantable lumen filter **100** may further incorporate one or more rings of struts (e.g., **409**, **909**, and **1009**, as shown in FIGS. 4 and 9-10, respectively).

FIGS. 2A-B illustrate another example implantable lumen filter **200**. In FIG. 2A, the implantable lumen filter **200** is shown in flattened form for ease of discussion. FIG. 2B illustrates a cross-sectional view of the implantable lumen filter **200** along the line 2B-2B shown in FIG. 2A. The example implantable lumen filter **200** of this configuration may be functionally similar to the example implantable lumen filter

100 previously described above and shown in FIGS. 1A-B in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter 200 may incorporate at least one component of the implantable lumen filters 100, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, and 1200 described in connection with FIGS. 1 and 3-12, respectively.

The implantable lumen filter 200 may include a body 202 having a proximal end 202a and a distal end 202b. The proximal end 202a may be the end of the body 202 that is closest to a user as the implantable lumen filter 200 is advanced into a body lumen. In other configurations, the proximal end 202a may be the end of the body 202 that is farthest from a user. The body 202 may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 2A-B in the expanded state. The implantable lumen filter 200 may also include one or more retrieval portions 230a, 230b coupled to the body 202 for retrieving the body 202 from a lumen.

The body 202 of the example implantable lumen filter 200 may include an outer surface 204 defined by a plurality of outer struts 206. The body 202 may include a proximal portion 203a and a distal portion 203b. The proximal portion 203a of the body 202 may include a proximal outer surface 204b defined by a plurality of proximal outer struts 206a. In the illustrated configuration, the proximal outer struts 206a extend longitudinally from the proximal end 202a toward an apex 205. At least some of the plurality of outer struts 206a extend generally in alignment with a longitudinal axis 201. The proximal outer surface 204a, in the illustrated configuration, may have a generally tapered shape from the apex 205 to the proximal end 202a.

The distal portion 203b may include a distal outer surface 204b defined by a plurality of distal outer struts 206b. In the illustrated configuration, the distal outer struts 206b extend longitudinally from the distal end 202b toward the apex 205 generally in alignment with the longitudinal axis 201. The distal outer surface 204b, in the illustrated configuration, may have a generally tapered shape from the apex 205 to the distal end 202b.

The implantable lumen filter 200 may be generally narrower near the proximal end 202a and distal end 202b with the apex 205 of the body 202 being a generally wider portion of the implantable lumen filter 200. The apex 205 may operate to anchor the implantable lumen filter 200 against the inner wall of a lumen. For example, in its expanded/deployed state, the body 202 may have an outer dimension 212 at or near the apex 205 which is similar to the inner dimension of the lumen wall.

The apex 205 may be configured to engage an inner surface of the body lumen. The surface area and/or other features of the apex 205 may be determined to facilitate engagement of the inner wall of the body lumen. The apex 205 may also facilitate alignment within the body lumen by controlling the surface area of the implantable lumen filter 200 to be in contact with the body lumen, by increasing the radial force applied by the implantable lumen filter 200, by other features, and/or combinations of the same.

The apex 205, in the illustrated configuration, may include a generally angular shape. In further configurations, however, the apex 205 may be less angular and more rounded or planar. Near the apex 205, the outer surface 204 is typically more varying in its shape than the remainder of the outer surface 204, such as the proximal outer surface 204a or the distal

outer surface 204b, which typically include a more constant surface shape that tapers from the proximal end 202a or from the distal end 202b towards the apex 205.

The example implantable lumen filter 200 also may include a plurality of inner struts 207. The plurality of inner struts 207 may attach to and extend from one or more outer struts 206. At least some of the plurality of inner struts 207 may extend longitudinally, generally in parallel with the longitudinal axis 201. In further configurations, one or more inner struts 207 may extend in any direction within the body 202 in order to achieve a desired result. The plurality of inner struts 207 may define an inner dimension 213. The outer dimension 212 and inner dimension 213 may define an annular region 216 extending around the body 202. The plurality of inner struts 207 may be configured to inhibit and/or lyse particulates flowing within or near the annular region 216.

The inner dimension 213 can vary with respect to the outer dimension 212 as desired according to multiple configurations. For example, the inner dimension 213 can range from about 5% to about 95% of the outer dimension 212. In a further example, the inner dimension 213 can range from about 25% to about 75% of the outer dimension 212. In an even further example, the inner dimension 213 can be about half of the outer dimension 212.

The body 202 may also include a first longitudinal dimension 214 and a second longitudinal dimension 215. The first longitudinal dimension 214 may extend from the proximal end 202a to the apex 205 generally parallel with the longitudinal axis 201 and represent the longitudinal length of the proximal portion 203a. The second longitudinal dimension 215 may extend from the distal end 202b to the apex 205 generally parallel with the longitudinal axis 201 and represent the longitudinal length of the distal portion 203b. The first longitudinal dimension 214 and second longitudinal dimension 215 may be substantially equal or may differ with the first longitudinal dimension 214 being longer or shorter than the second longitudinal dimension 215.

The struts 206, 207 may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the outer struts 206. In configurations where the body 202 is not defined by outer struts 206, the structure defining the body 202 may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body 202.

The outer struts 206 may be welded and/or otherwise connected together to form the body 202. For example, the body 202 may be formed by welding or otherwise connecting the proximal outer struts 206a and distal outer struts 206b together. In particular, the distal ends of the proximal outer struts 206a can be connected to the corresponding proximal ends of the distal outer struts 206b to form the body 202. In addition, the connection between the proximal outer struts 206a and distal outer struts 206b may at least partially define the apex 205 in the outer surface 204. In a further configuration, one or more outer struts 206 may extend as single pieces from the proximal end 202a to the distal end 202b and include bends and/or other features to define the apex 205.

The inner struts 207 may be welded or otherwise connected to the outer struts 206. For example, the inner struts 207 can be connected at one end to the distal outer struts 206b and at the other end to the proximal outer struts 206a. In addition, the inner struts 207 can be connected to the distal outer struts

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206b and/or the proximal outer struts **206a** at any point along the lengths of the distal outer struts **206b** and proximal outer struts **206a**. In the illustrated configuration, the inner struts **207** span the apex **205**, being connected at the ends to the outer struts **206**, the connections to the outer struts **206** being spaced a distance from the apex **205**.

The proximal outer struts **206a** may also be welded or otherwise connected together at the proximal end **202a**, while the distal outer struts **206b** may be welded or otherwise connected together at the distal end **202b**. In other configurations, the outer struts **206** may be formed by removing material from the body **202** using, for example, laser cutting and/or other material removing procedures.

The outer struts **206** may form a plurality of apertures **210** in the body **202**. In the configuration illustrated in FIGS. 2A-B, the example outer struts **206** form generally elongated, V-shaped apertures **210** extending between the outer struts **206** from the proximal end **202a** and distal end **202b** to the apex **205**, the apertures **210** defining wider openings near the apex **205** and narrower openings near the proximal and distal ends **202a**, **202b**, respectively. The number of outer struts **206** can be selectively determined to produce a desired spacing between adjacent outer struts **206** and a corresponding aperture **210** size and shape. In further configurations, the outer struts **206** may form apertures **210** having other shapes, such as diamond shapes, triangular shapes, chevron shapes, and/or other suitable shapes.

The proximal portion **203a** and distal portion **203b** may be generally symmetrical about a plane defined by the apex **205**. For example, the proximal and distal portions **203a**, **203b** can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends **202a**, **202b** respectively, and with the wider base portion of the cone being located at or near the apex **205**. In further configurations, the size and/or shape of the proximal portion **203a** can differ from the size and/or shape of the distal portion **203b**.

The implantable lumen filter **200** can be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body **202** of the implantable lumen filter **200** may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension **212** of the body **202** and/or an inner surface of a lumen wall.

In one example configuration, the implantable lumen filter **200** can be deployed within a body lumen such that the proximal portion **203a** is located on the upstream side of the implantable lumen filter **200**. The proximal portion **203a** can be configured to direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface **204a** towards the outer dimension **212** of the body **202**. For instance, when a particulate collides with the proximal outer surface **204a**, the proximal outer struts **206a** can deflect the particulate towards the lumen wall. Particulates may also travel along the proximal outer struts **206a** until they either reach an aperture in the body **202** large enough to pass through the body **202**, become lysed into smaller particulates small enough to pass through the body **202**, become collected between the proximal outer surface **204a** and the lumen wall, become collected by one or more outer struts **206a**, become collected within the annular region **216**, and/or combinations of the same.

Accordingly, the example implantable lumen filter **200** can direct particulates towards and cause particulates to be collected near the outer dimension **212** and/or within the annular region **216** of the body **202**. As a result, some aspects of the example implantable lumen filter **200** can limit or prevent blockage of the central portion of a lumen, thereby maintain-

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ing flow within the lumen for a longer period of time. Thus, the example implantable lumen filter **200** disclosed in FIGS. 2A-B can enhance the lifespan and durability of the implantable lumen filter **200**.

In a further embodiment, the implantable lumen filter **200** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **200** can be deployed with either the distal end **202b** or the proximal end **202a** positioned on the upstream side of the implantable lumen filter **200** within the lumen.

FIGS. 3A-B illustrate a further configuration of an implantable lumen filter **300**. In FIG. 3A, the implantable lumen filter **300** is shown in flattened form for ease of discussion. FIG. 3B illustrates a cross-sectional view of the implantable lumen filter **300** of FIG. 3A along the line 3B-3B. The implantable lumen filter **300** of this further configuration may be functionally similar to the implantable lumen filters **100**, **200** previously described above and shown in FIGS. 1-2 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **300** may incorporate at least one component of the implantable lumen filters **100**, **200**, **400**, **500**, **600**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. 1-2 and 4-12, respectively.

The implantable lumen filter **300** may include a body **302** having a proximal end **302a** and a distal end **302b**. The proximal end **302a** may be the end of the body **302** that is closest to a user as the implantable lumen filter **300** is advanced into a body lumen. In other configurations, the proximal end **302a** may be the end of the body **302** that is farthest from a user. The body **302** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 3A-B in the expanded state. The implantable lumen filter **300** may also include one or more retrieval portions **330a**, **330b** coupled to the body **302** for retrieving the body **302** from a lumen.

The body **302** of the example implantable lumen filter **300** may include an outer surface **304** defined by a plurality of outer struts **306**. The body **302** may include a proximal portion **303a** and a distal portion **303b**. The proximal portion **303a** of the body **302** may include a proximal outer surface **304b** defined by a plurality of proximal outer struts **306a**. In the illustrated configuration, the proximal outer struts **306a** extend longitudinally from the proximal end **302a** toward an apex **305** generally in alignment with the longitudinal axis **301**. The proximal outer surface **304a**, in the illustrated configuration, may have a generally tapered shape from the proximal end **302a** to the apex **305**.

The distal portion **303b** may include a distal outer surface **304b** defined by a plurality of outer struts **306b**. In the illustrated configuration, the distal outer struts **306b** extend longitudinally from the distal end **302b** toward the apex **305** generally in alignment with the longitudinal axis **301**. The distal outer surface **304b**, may have a generally tapered shape from the distal end **302b** to the apex **305**.

The example implantable lumen filter **300** may also include a plurality of overhanging outer struts **306c**. The overhanging outer struts **306c** may be connected to the body **302** proximate the apex **305** and extend in alignment with the longitudinal axis **301** towards the proximal end **302a**, overhanging at least a portion of the proximal outer surface **304a**. The overhanging outer struts **306c** may at least partially define an outer dimension **312** and an annular region **316** extending around the body **302a** at or near the apex **305** of the

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body 302. The annular region 316 may be configured to collect and/or inhibit particulates flowing within the lumen.

The proximal outer struts 306a may at least partially define an inner dimension 313 of the annular region 316. The inner dimension 313 can vary with respect to the outer dimension 312 as desired according to multiple configurations. For example, the inner dimension 313 can range from about 5% to about 95% of the outer dimension 312. In a further example, the inner dimension 313 can range from about 25% to about 75% of the outer dimension 312. In an even further example, the inner dimension 313 can be about half of the outer dimension 312.

The implantable lumen filter 300 may be generally narrower near the proximal end 302a and distal end 302b with the apex 305 of the body 302 being a generally wider portion of the implantable lumen filter 300. The apex 305 may operate to anchor the implantable lumen filter 300 against the inner wall of a lumen. For example, in its expanded/deployed state, the body 302 may have an outer dimension 312 at or near the apex 305 which is similar to an inner dimension of the lumen wall. The apex 305 may also import a radial force to an inner surface of the body lumen.

The body 302 may also include a first longitudinal dimension 314 and a second longitudinal dimension 315. The first longitudinal dimension 314 may extend from the proximal end 302a to the apex 305 generally parallel with the longitudinal axis 301 and represent the longitudinal length of the proximal portion 303a. The second longitudinal dimension 315 may extend from the distal end 302b to the apex 305 generally parallel with the longitudinal axis 301 and represent the longitudinal length of the distal portion 303b. The first longitudinal dimension 314 and second longitudinal dimension 315 may be substantially equal or may differ with the first longitudinal dimension 314 being longer or shorter than the second longitudinal dimension 315.

The struts 306 of the body 302 may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the struts 306. In configurations where the body 302 is not defined by outer struts 306, the structure defining the body 302 may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body 302.

The struts 306 may be welded and/or otherwise connected together to form the body 302. For example, the body 302 may be formed by welding or otherwise connecting the proximal outer struts 306a, distal outer struts 306b, and overhanging outer struts 306c together. In particular, the distal ends of the proximal outer struts 306a can be connected to the corresponding proximal ends of the distal outer struts 306b to form the body 302. In addition, the connection between the proximal outer struts 306a and distal outer struts 306b may at least partially define the apex 305 in the outer surface 304. In a further configuration, one or more outer struts 306 may extend as single pieces from the proximal end 302a to the distal end 302b and include bends and/or other features to at least partially define the apex 305.

The overhanging struts 306c may be welded or otherwise connected at one end to the distal outer struts 306b and/or the proximal outer struts 306a at or near the apex 305. In other configurations, the overhanging struts 306c may include portions of the distal outer struts 306b extending beyond their connection with the proximal outer struts 306a.

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The proximal outer struts 306a may also be welded or otherwise connected together at the proximal end 302a, while the distal outer struts 306b may be welded or otherwise connected together at the distal end 306b. In other configurations, the outer struts 306 may be formed by removing material from the body 302 using, for example, laser cutting and/or other material removing procedures.

The outer struts 306 may form a plurality of apertures 310 in the body 302. In the configuration illustrated in FIGS. 3A-B, the example outer struts 306 form generally elongated, V-shaped apertures extending between the outer struts 306 from the proximal end 302a and distal end 302b to the apex 305, the apertures 310 defining wider openings near the apex 305 and narrower openings near the proximal and distal ends 302a, 302b, respectively. The number of outer struts 306 can be selectively determined to produce a desired spacing between adjacent outer struts 306 and a corresponding aperture 310 size and shape. In further configurations, the outer struts 306 may form apertures 310 having other shapes, such as diamond shapes, triangular shapes, chevron shapes, and/or other suitable shapes.

The proximal portion 303a and distal portion 303b may be generally symmetrical about a plane defined by the apex 305. For example, the proximal and distal portions 303a, 303b can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends 302a, 302b respectively, and with the wider base portion of the cone being located at or near the apex 305. In further configurations, the size and/or shape of the proximal portion 303a can differ from the size and/or shape of the distal portion 303b.

The implantable lumen filter 300 may be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body 302 of the implantable lumen filter 300 may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension 312 and/or annular region 316 of the body 302 and/or the inner surface of a lumen wall.

In one example configuration, the implantable lumen filter 300 can be deployed within a body lumen with the proximal portion 303a located on the upstream side of the implantable lumen filter 300. The proximal portion 303a can direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface 304a so as to collect proximate the apex 305 and/or within the annular region 316 of the body 302. For instance, when a particulate collides with the proximal outer surface 304a, the proximal outer struts 306a can deflect the particulate towards the lumen wall. Particulates may also travel along the longitudinally extending outer struts 306a until they either reach an aperture in the body 302 large enough to pass through the body, become lysed into smaller particulates small enough to pass through the body 302, become collected between the proximal outer surface 304a and the lumen wall, become collected by one or more outer struts 306a, become collected within or rear the annular region 316, and/or combinations of the same.

Accordingly, the example implantable lumen filter 300 can direct particulates towards and cause particulates to be collected near the outer dimension 312 and/or within the annular region 316 of the body 302. As a result, some aspects of the example implantable lumen filter 300 can limit or prevent blockage of the central portion of a lumen, thereby maintaining flow within the lumen. Thus, the example implantable lumen filter 300 disclosed in FIGS. 3A-B can enhance the lifespan and durability of the implantable lumen filter 300.

In a further embodiment, the implantable lumen filter 300 can be interchangeably deployed within a lumen. For

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example, the implantable lumen filter **300** can be deployed with either the distal end **302b** or the proximal end **302a** positioned on the upstream side of the implantable lumen filter **300** within the lumen.

The overhanging struts **303c** may enhance the retention of particulates collected upon the implantable lumen filter **300** while the implantable lumen filter **300** is retrieved from a lumen. For example, as the implantable lumen filter **300** is elongated and the apex **305** disengages the lumen wall, the overhanging struts **303c** may function to retain collected particulates within the annular region **316**, thereby preventing the collected particulates from flowing past the implantable lumen filter **300** and back into the fluid flow of the lumen.

FIGS. 4A-B illustrate a still further configuration of an example implantable lumen filter **400**. In FIG. 4A, the implantable lumen filter **400** is shown in flattened form for ease of discussion. FIG. 4B illustrates an end view of the implantable lumen filter **400** of FIG. 4A. The implantable lumen filter **400** of this further configuration may be functionally similar to the example implantable lumen filters **100**, **200**, **300** previously described above and shown in FIGS. 1-3 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **400** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **500**, **600**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. 1-3 and 5-12, respectively.

The implantable lumen filter **400** may include a body **402** having a proximal end **402a** and a distal end **402b**. The proximal end **402a** may be the end of the body **402** that is closest to a user as the implantable lumen filter **400** is advanced into a body lumen. In other configurations, the proximal end **402a** may be the end of the body **402** that is farthest from a user. The body **402** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 4A-B in the expanded state. The implantable lumen filter **400** may also include one or more retrieval portions **430a**, **430b** coupled to the body **402** for retrieving the body **402** from a lumen.

The body **402** of the example implantable lumen filter **400** may include an outer surface **404** defined by a plurality of outer struts **406**. The body **402** may include a proximal portion **403a** and a distal portion **403b**. The proximal portion **403a** of the body **402** may include a proximal outer surface **404b** defined by a plurality of proximal outer struts **406a**. In the illustrated configuration, at least some of the proximal outer struts **406a** extend longitudinally from the proximal end **402a** toward an apex **405** in the outer surface **404** of the body **402**. The proximal outer surface **404a**, in the illustrated configuration, may have a generally tapered shape from the apex **405** to the proximal end **402a**.

A portion of the plurality of proximal outer struts **406b** may form one or more rings **409** extending around the proximal outer surface **404a**. The one or more rings **409** may at least partially define an outer dimension **412**, an inner dimension **413**, and/or an annular region **416** at or near the apex **405** in the outer surface **404** of the body **402**. The inner dimension **413** can vary with respect to the outer dimension **412** as desired according to multiple configurations. For example, the inner dimension **413** can range from about 5% to about 95% of the outer dimension **412**. In a further example, the inner dimension **413** can range from about 25% to about 75%

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of the outer dimension **412**. In an even further example, the inner dimension **413** can be about half of the outer dimension **412**.

The one or more rings **409** may include one or more points **417**. The points **417** may be configured to inhibit, lyse, and/or impale particulates flowing within a lumen. As shown in the illustrated configuration, the points **417** can be angled inward toward the longitudinal axis **401**. In a further example, the points **417** can be angled in any direction desired, such as in parallel with the longitudinal axis **401** or outward towards the apex **405**.

The distal portion **403b** may include a distal outer surface **404b** defined by a plurality of outer struts **406b**. In the illustrated configuration, at least some of the distal outer struts **406b** extend longitudinally from the distal end **402b** toward the apex **405** generally in alignment with the longitudinal axis **401**. The distal outer struts **406b** may also form one or more rings **409** extending around the distal outer surface **404b**. The distal outer surface **404b**, in the illustrated configuration, may have a generally tapered shape from the apex **405** to the distal end **402b**.

The implantable lumen filter **400** may be generally narrower near the proximal end **402a** and distal end **402b** with the apex **405** of the body **402** being a generally wider portion of the implantable lumen filter **400**. The apex **405** may operate to anchor the implantable lumen filter **400** against an inner wall of a lumen. For example, in its expanded/deployed state, the body **402** may have an outer dimension **412** at or near the apex **405** which is similar to an inner dimension of the lumen wall. The apex **405** may also impart a radial force to an inner surface of the body lumen.

The body **402** may also include a first longitudinal dimension **414** and a second longitudinal dimension **415**. The first longitudinal dimension **414** may extend from the proximal end **402a** to the apex **405** generally parallel with the longitudinal axis **401** and represent the longitudinal length of the proximal portion **403a**. The second longitudinal dimension **415** may extend from the distal end **402b** to the apex **405** generally parallel with the longitudinal axis **401** and represent the longitudinal length of the distal portion **403b**. The first longitudinal dimension **414** and second longitudinal dimension **415** may be substantially equal or may differ with the first longitudinal dimension **414** being longer or shorter than the second longitudinal dimension **415**.

The outer struts **406** of the body **402** may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the outer struts **406**. In configurations where the body **402** is not defined by outer struts **406**, the structure defining the body **402** may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body **402**.

The outer struts **406** may be welded and/or otherwise connected together to form the body **402**. For example, the body **402** may be formed by welding or otherwise connecting the distal outer struts **406b** and the proximal outer struts **406a** together. In addition, one or more outer struts **406** may be connected together to form the rings **409**. In a further configuration, one or more outer struts **406** may extend as single pieces from the proximal end **402a** to the distal end **402b** and include bends and/or other features to define the apex **405**.

The proximal outer struts **406a** may also be welded or otherwise connected together at the proximal end **402a**, while the distal outer struts **406b** may be welded or otherwise connected together at the distal end **406b**. In other configurations, the outer struts **406** may be formed by removing material from the body **402** using, for example, laser cutting and/or other material removing procedures.

The outer struts **406** may form a plurality of apertures **410** in the body **402**. In the configuration illustrated in FIGS. 4A-B, the example outer struts **406** form generally elongated, V-shaped apertures extending between the outer struts **406** from the proximal end **402a** and distal end **402b** to near the apex **405**, the apertures **410** defining wider openings near the apex **405** and narrower openings near the proximal and distal ends **402a**, **402b**, respectively. The number of outer struts **406** can be selectively determined to produce a desired spacing between adjacent outer struts **406** and a corresponding aperture **410** size and shape. In addition, the rings **409** may form differently shaped apertures **410** in the annular region **416** of the body **402**. In further configurations, the outer struts **406** may form apertures **410** having other shapes, such as diamond shapes, triangular shapes, chevron shapes, and/or other suitable shapes.

The proximal portion **403a** and distal portion **403b** may be generally symmetrical about a plane defined by the apex **405**. For example, the proximal and distal portions **403a**, **403b** can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends **402a**, **402b** respectively, and with the wider base portion of the cone being located at or near the apex **405**. In further configurations, the size and/or shape of the proximal portion **403a** can differ from the size and/or shape of the distal portion **403b**.

The implantable lumen filter **400** can be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body **402** of the implantable lumen filter **400** may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension **412** and/or annular region **416** of the body **402** and/or a lumen wall.

In one example configuration, the implantable lumen filter **400** can be deployed within a body lumen such that the proximal portion **403a** is located on the upstream side of the implantable lumen filter **400**. The proximal portion **403a** can be configured to direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface **404a** so as to collect proximate the outer dimension **412** of the body **402**. For instance, when a particulate collides with the proximal outer surface **404a**, the proximal outer struts **406a** can deflect the particulate towards the lumen wall. Particulates may also travel along the longitudinally extending outer struts **406a** until they either reach an aperture in the body **402** large enough to pass through the body, become lysed into smaller particulates small enough to pass through the body **402**, become collected between the proximal outer surface **404a** and the lumen wall, become collected by one or more outer struts **406a**, become collected within the annular region **416**, and/or combinations of the same.

Accordingly, the example implantable lumen filter **400** can direct particulates towards and cause particulates to be collected near the outer dimension **412** and/or within the annular region **416** of the body **402**. As a result, some aspects of the example implantable lumen filter **400** can limit or prevent blockage of the central portion of a lumen, thereby maintaining flow within the lumen. Thus, the example implantable lumen filter **400** disclosed in FIGS. 4A-B can enhance the lifespan and durability of the implantable lumen filter **400**.

In a further embodiment, the implantable lumen filter **400** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **400** can be deployed with either the distal end **402b** or the proximal end **402a** positioned on the upstream side of the implantable lumen filter **400** within the lumen.

FIGS. 5A-B illustrate a yet further configuration of an implantable lumen filter **500**. In FIG. 5A, the implantable lumen filter **500** is shown in flattened form for ease of discussion. FIG. 5B illustrates an end view of the implantable lumen filter **500** of FIG. 5A. The implantable lumen filter **500** of this other configuration may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400** previously described above and shown in FIGS. 1-4 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **500** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **600**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. 1-4 and 6-12, respectively.

The implantable lumen filter **500** may include a body **502** having a proximal end **502a** and a distal end **502b**. The proximal end **502a** may be the end of the body **502** that is closest to a user as the implantable lumen filter **500** is advanced into a body lumen. In other configurations, the proximal end **502a** may be the end of the body **502** that is farthest from a user. The body **502** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 5A-B in the expanded state. The implantable lumen filter **500** may also include one or more retrieval portions **530a**, **530b** coupled to the body **502** for retrieving the body **502** from a lumen.

The body **502** of the example implantable lumen filter **500** may include an outer surface **504** defined by a plurality of outer struts **506**. The body **502** may include a proximal portion **503a** and a distal portion **503b**. The proximal portion **503a** of the body **502** may include a proximal outer surface **504b** defined by a plurality of proximal outer struts **506a**. In the illustrated configuration, portions of the proximal outer struts **506a** extend longitudinally from the proximal end **502a** toward an apex **505** generally in alignment with the longitudinal axis **501**. In addition, further portions of the proximal outer struts **506a** can be bent and/or angled in a direction away from parallel with the longitudinal axis **501**. The proximal outer surface **504a**, in the illustrated configuration, may have a generally tapered shape from the proximal end **502a** to the apex **505**.

The angled portions **506a'** of the proximal outer struts **506a** may at least partially define an outer dimension **512**, an inner dimension **513**, and an annular region **516** at or near the apex **505** of the body **502**. The inner dimension **513** can vary with respect to the outer dimension **512** as desired according to multiple configurations. For example, the inner dimension **513** can range from about 5% to about 95% of the outer dimension **512**. In a further example, the inner dimension **513** can range from about 25% to about 75% of the outer dimension **512**. In an even further example, the inner dimension **513** can be about half of the outer dimension **512**.

The distal portion **503b** may include a distal outer surface **504b** defined by a plurality of outer struts **506b**. In the illustrated configuration, the distal outer struts **506b** extend longitudinally from the distal end **502b** toward the apex **505** generally in alignment with the longitudinal axis **501**. The

distal outer surface **504b**, in the illustrated configuration, may have a generally tapered shape from the distal end **502b** to the apex **505**.

The implantable lumen filter **500** may be generally narrower near the proximal end **502a** and distal end **502b** with the apex **505** of the body **502** being a generally wider portion of the implantable lumen filter **500**. The apex **505** may operate to anchor the implantable lumen filter **500** against an inner wall of a lumen. For example, in its expanded/deployed state, the body **502** may have an outer dimension **512** at or near the apex **505** which is similar to the inner dimension of the lumen wall. The apex **505** may also impart a radial force to an inner surface of the body lumen.

The body **502** may also include a first longitudinal dimension **514** and a second longitudinal dimension **515**. The first longitudinal dimension **514** may extend from the proximal end **502a** to the apex **505** generally parallel with the longitudinal axis **501** and represent the longitudinal length of the proximal portion **503a**. The second longitudinal dimension **515** may extend from the distal end **502b** to the apex **505** generally parallel with the longitudinal axis **501** and represent the longitudinal length of the distal portion **503b**. The first longitudinal dimension **514** and second longitudinal dimension **515** may be substantially equal or may differ with the first longitudinal dimension **514** being longer or shorter than the second longitudinal dimension **515**.

The outer struts **506** of the body **502** may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the outer struts **506**. In configurations where the body **502** is not defined by outer struts **506**, the structure defining the body **502** may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body **502**.

The outer struts **506** may be welded and/or otherwise connected together to form the body **502**. For example, the body **502** may be formed by welding or otherwise connecting the proximal outer struts **506a** and distal outer struts **506b** together. In particular, the distal ends of the proximal outer struts **506a** can be connected to the corresponding proximal ends of the distal outer struts **506b** to form the body **502**. In addition, the connection between the proximal outer struts **506a** and distal outer struts **506b** may at least partially define the apex **505** in the outer surface **504**. In a further configuration, one or more outer struts **506** may extend as single pieces from the proximal end **502a** to the distal end **502b** and include bends and/or other features to define the apex **505**.

The proximal outer struts **506a** may also be welded or otherwise connected together at the proximal end **502a**, while the distal outer struts **506b** may be welded or otherwise connected together at the distal end **502b**. In other configurations, the outer struts **506** may be formed by removing material from the body **502** using, for example, laser cutting and/or other material removing procedures.

The outer struts **506** may form a plurality of apertures **510** in the body **502**. In the configuration illustrated in FIGS. 5A-B, the example outer struts **506** form generally elongated, V-shaped apertures extending between the outer struts **506** from the proximal end **502a** and distal end **502b** towards the apex **505**, the apertures **510** defining wider openings near the apex **505** and narrower openings near the proximal and distal ends **502a**, **502b**, respectively. The number of outer struts **506**

can be selectively determined to produce a desired spacing between adjacent outer struts **506** and a corresponding aperture **510** size and shape. In further configurations, the outer struts **506** may form apertures **510** having other shapes, such as diamond shapes, triangular shapes, chevron shapes, and/or other suitable shapes.

The proximal portion **503a** and distal portion **503b** may be generally symmetrical about a plane defined by the apex **505**. For example, the proximal and distal portions **503a**, **503b** can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends **502a**, **502b** respectively, and with the wider base portion of the cone being located at or near the apex **505**. In further configurations, the size and/or shape of the proximal portion **503a** can differ from the size and/or shape of the distal portion **503b**.

The implantable lumen filter **500** can be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body **502** of the implantable lumen filter **500** may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension **512** of the body **502** and/or a lumen wall.

In one example configuration, the implantable lumen filter **500** can be deployed within a body lumen with the proximal portion **503a** being located on the upstream side of the implantable lumen filter **500**. The proximal portion **503a** can be configured to direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface **504a** so as to collect proximate the outer dimension **512** of the body **502**. For instance, when a particulate collides with the proximal outer surface **504a**, the proximal outer struts **506a** can deflect the particulate towards the lumen wall. Particulates may travel along the longitudinally extending outer struts **506a** until they either reach an aperture in the body **502** large enough to pass through the body, become lysed into smaller particulates small enough to pass through the body **502**, become collected between the proximal outer surface **504a** and the lumen wall, become collected by one or more outer struts **506a**, become collected within or near the annular region **516**, and/or combinations of the same.

Accordingly, the example implantable lumen filter **500** can direct particulates towards and cause particulates to be collected near the outer dimension **512** and/or within the annular region **516** of the body **502**. As a result, some aspects of the example implantable lumen filter **500** can limit or prevent blockage of the central portion of a lumen, thereby maintaining flow within the lumen for a longer period of time. Thus, the example implantable lumen filter **500** disclosed in FIGS. 5A-B can enhance the lifespan and durability of the implantable lumen filter **500**.

In a further embodiment, the implantable lumen filter **500** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **500** can be deployed with either the distal end **502b** or the proximal end **502a** positioned on the upstream side of the implantable lumen filter **500** within the lumen.

FIGS. 6A-B illustrate another configuration of an implantable lumen filter **600**. In FIG. 6A, the implantable lumen filter **600** is shown in flattened form for ease of discussion. FIG. 6B illustrates a cross-sectional view of the implantable lumen filter **600** of FIG. 6A along the line 6B-6B. The implantable lumen filter **600** of this other configuration may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500** previously described above and shown in FIGS. 1-5 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and

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are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **600** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **700**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. **1-5** and **7-12**, respectively.

The implantable lumen filter **600** may include a body **602** having a proximal end **602a** and a distal end **602b**. The proximal end **602a** may be the end of the body **602** that is closest to a user as the implantable lumen filter **600** is advanced into a body lumen. In other configurations, the proximal end **602a** may be the end of the body **602** that is farthest from a user. The body **602** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. **6A-B** in the expanded state. The implantable lumen filter **600** may also include one or more retrieval portions **630a**, **630b** coupled to the body **602** for retrieving the body **602** from a lumen.

The body **602** of the example implantable lumen filter **600** may include an outer surface **604** defined by a plurality of outer struts **606**. The body **602** may include a proximal portion **603a** and a distal portion **603b**. The proximal portion **603a** of the body **602** may include a proximal outer surface **604b** defined by a plurality of proximal outer struts **606a**. In the illustrated configuration, the proximal outer struts **606a** extend longitudinally from the proximal end **602a** toward an apex **605** generally in alignment with the longitudinal axis **601**. The proximal outer surface **604a**, in the illustrated configuration, may have a generally tapered shape from the proximal end **602a** to the apex **605**.

The distal portion **603b** may include a distal outer surface **604b** defined by a plurality of outer struts **606b**. In the illustrated configuration, the distal outer struts **606b** extend longitudinally from the distal end **602b** toward the apex **605** generally in alignment with the longitudinal axis **601**. The distal outer surface **604b**, in the illustrated configuration, may have a generally tapered shape from the distal end **602b** to the apex **605**.

The example implantable lumen filter **600** may also include a plurality of overhanging outer struts **606c**. The overhanging outer struts **606c** may be located proximate, and may at least partially define the apex **605**. The overhanging outer struts **606c** can angle outwards and overhang at least a portion of the proximal outer surface **604a**. The overhanging outer struts **606c** may at least partially define an outer dimension **612** and an annular region **616** extending around the body **602** at or near the apex **605**. The annular region **616** may be configured to collect and/or inhibit particulates flowing within the lumen. In one example configuration, the overhanging struts **606c** may be formed by portions of the distal outer struts **606b** overhanging a connection with the proximal outer struts **606a**.

The proximal outer struts **606a** may at least partially define an inner dimension **613** of the annular region **616**. The inner dimension **613** can vary with respect to the outer dimension **612** as desired according to multiple configurations. For example, the inner dimension **613** can range from about 5% to about 95% of the outer dimension **612**. In a further example, the inner dimension **613** can range from about 25% to about 75% of the outer dimension **612**. In an even further example, the inner dimension **613** can be about half of the outer dimension **612**.

The implantable lumen filter **600** may be generally narrower near the proximal end **602a** and distal end **602b** with the apex **605** of the body **602** being a generally wider portion of the implantable lumen filter **600**. The apex **605** may operate to anchor the implantable lumen filter **600** against an inner

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wall of a lumen. For example, in its expanded/deployed state, the body **602** may have an outer dimension **612** at or near the apex **605** which is similar to the inner dimension of the lumen wall.

The body **602** may also include a first longitudinal dimension **614** and a second longitudinal dimension **615**. The first longitudinal dimension **614** may extend from the proximal end **602a** to the apex **605** generally parallel with the longitudinal axis **601** and represent the longitudinal length of the proximal portion **603a**. The second longitudinal dimension **615** may extend from the distal end **602b** to the apex **605** generally parallel with the longitudinal axis **601** and represent the longitudinal length of the distal portion **603b**. The first longitudinal dimension **614** and second longitudinal dimension **615** may be substantially equal or may differ with the first longitudinal dimension **614** being longer or shorter than the second longitudinal dimension **615**.

The outer struts **606** of the body **602** may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the outer struts **606**. In configurations where the body **602** is not defined by outer struts **606**, the structure defining the body **602** may be formed from these various materials and/or may have at least one beneficial agent incorporated into the material of and/or coated over at least a portion of the material. For instance, an anti-thrombotic beneficial agent may be coated over at least a portion of the body **602**.

The overhanging struts **606c** may be welded or otherwise connected at one end to the distal outer struts **606b** and/or the proximal outer struts **606a** at or near the apex **605**. In other configuration, the overhanging struts **606c** may include portions of the distal outer struts **606b** extending beyond their connection with the proximal outer struts **606a**.

The proximal outer struts **606a** may also be welded or otherwise connected together at the proximal end **602a**, while the distal outer struts **606b** may be welded or otherwise connected together at the distal end **602b**. In other configurations, the outer struts **606** may be formed by removing material from the body **602** using, for example, laser cutting and/or other material removing procedures.

The outer struts **606** may form a plurality of apertures **610** in the body **602**. In the configuration illustrated in FIGS. **6A-B**, the example outer struts **606** form generally elongated, V-shaped apertures extending between the outer struts **606** from the proximal end **602a** and distal end **602b** to the apex **605**, the apertures **610** defining wider openings near the apex **605** and narrower openings near the proximal and distal ends **602a**, **602b**, respectively. The number of outer struts **606** can be selectively determined to produce a desired spacing between adjacent outer struts **606** and a corresponding aperture **610** size and shape. In further configurations, the outer struts **606** may form apertures **610** having other shapes, such as diamond shapes, triangular shapes, chevron shapes, and/or other suitable shapes.

The proximal portion **603a** and distal portion **603b** may be generally symmetrical about a plane defined by the apex **605**. For example, the proximal and distal portions **603a**, **603b** can each incorporate a substantially conical shape with the tip end of the cone being located at the proximal and distal ends **602a**, **602b** respectively, and with the wider base portion of the cone being located at or near the apex **605**. In further configurations, the size and/or shape of the proximal portion **603a** can differ from the size and/or shape of the distal portion **603b**.

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The implantable lumen filter **600** may be configured to direct particulates within a body lumen in a radially-outward direction. In particular, the body **602** of the implantable lumen filter **600** may be shaped, sized, and/or oriented to facilitate direction of particulates within the lumen towards the outer dimension **612** and/or annular region **616** of the body **602** and/or the inner surface of a lumen wall.

In one example configuration, the implantable lumen filter **600** can be deployed within a body lumen with the proximal portion **603a** being located on the upstream side of the implantable lumen filter **600**. The proximal portion **603a** can direct particulates flowing within the lumen radially outward. In particular, the particulates can be directed by the proximal outer surface **604a** towards the apex **605** and/or the annular region **616** of the body **602**. For instance, when a particulate collides with the proximal outer surface **604a**, the proximal outer struts **606a** can deflect the particulate radially outward. Particulates may also travel along the longitudinally extending outer struts **606a** until they either reach an aperture in the body **602** large enough to pass through the body, become lysed into smaller particulates small enough to pass through the body **602**, become collected between the proximal outer surface **604a** and the lumen wall, become collected by one or more outer struts **606a**, become collected within the annular region **616**, and/or combinations of the same.

Accordingly, the example implantable lumen filter **600** can direct particulates towards and cause particulates to be collected near the outer dimension **612** and/or within the annular region **616** of the body **602**. As a result, some aspects of the example implantable lumen filter **600** can limit or prevent blockage of the central portion of a lumen, thereby maintaining flow within the lumen. Thus, the example implantable lumen filter **600** disclosed in FIGS. 6A-B can enhance the lifespan and durability of the implantable lumen filter **600**.

In a further embodiment, the implantable lumen filter **600** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **600** can be deployed with either the distal end **602b** or the proximal end **602a** positioned on the upstream side of the implantable lumen filter **600** within the lumen.

The overhanging struts **603c** may enhance the retention of particulates collected upon the implantable lumen filter **600** while the implantable lumen filter **600** is retrieved from a lumen. For example, as the implantable lumen filter **600** is elongated and the apex **605** disengages the lumen wall, the overhanging struts **603c** may function to retain collected particulates within the annular region **616**, thereby preventing the collected particulates from flowing past the implantable lumen filter **600** and back into the fluid flow of the lumen.

FIGS. 7A-B illustrate another configuration of an implantable lumen filter **700**. In FIG. 7A, the implantable lumen filter **700** is shown in flattened form for ease of discussion. FIG. 7B illustrates an end view of the implantable lumen filter **700** of FIG. 7A. The implantable lumen filter **700** of this other configuration may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600** previously described above and shown in FIGS. 1-6 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **700** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **800**, **900**, **1000**, **1100**, and **1200** described in connection with FIGS. 1-6 and 8-12, respectively.

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The implantable lumen filter **700** is shown in flattened form for ease of discussion. The implantable lumen filter **700** may include a body **702** having a proximal end **702a** and a distal end **702b**. The proximal end **702a** may be the end of the body **702** that is closest to a user as the implantable lumen filter **700** is advanced into a body lumen. In other configurations, the proximal end **702a** may be the end of the body **702** that is farthest from a user. The body **702** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 7A-B in the expanded state. The implantable lumen filter **700** may also include one or more retrieval portions **730** coupled to the body **702** for retrieving the body **702** from a lumen.

The body **702** may define an outer surface **704** being defined by a plurality of struts **706**. The outer surface **704**, in the illustrated configuration, may have a generally tapered shape from the proximal end **702a** toward the distal end **702b**. A generally tapered shape may include a line and/or curve tapered toward and rotated about a longitudinal axis **701**, a generally right circular conic outer surface, a generally oblique conic outer surface, and/or other shapes that generally taper toward the one end.

The distal end **702b**, in the illustrated configuration, may be a generally more narrow portion of the implantable lumen filter **700** with the proximal end **702a** being a generally wider portion of the implantable lumen filter **700**. Alternatively, the distal end **702b** may be a generally wider portion of the implantable lumen filter **700** with the proximal end **702a** being a more narrow portion of the implantable lumen filter **700**.

The implantable lumen filter **700** may also include a plurality of inner struts **707** extending inwards from the plurality of outer struts **706**. For example, the inner struts **707** may be attached to the outer struts **706** a distance away from the proximal end **702a** and extend towards the proximal end **702a**. The plurality of inner struts **707** may form one or more points **717**. The points **717** may be configured to inhibit, lyse, and/or impale particulates flowing within a lumen. The inner struts **707** can extend in a direction generally parallel with the longitudinal axis **701**, or can be angled in any direction desired for a particular application. In addition, the number of inner struts **707** included in the body **702**, and the position and number of inner struts **707** attached to each outer strut **706** can be varied as desired for each particular application.

The outer struts **706** may define, near the proximal end **702a**, an outer dimension **712** of the body **702**, while the inner struts **707** may define an inner dimension **713**. The outer dimension **712** and inner dimension **713** may define an annular region **716** extending around the body **702** at or near the proximal end **702a**. The inner dimension **713** can vary with respect to the outer dimension **712** as desired according to multiple configurations. For example, the inner dimension **713** can range from about 5% to about 95% of the outer dimension **712**. In a further example, the inner dimension **713** can range from about 25% to about 75% of the outer dimension **712**. In an even further example, the inner dimension **713** can be about half of the outer dimension **712**.

The implantable lumen filter **700** may be configured to inhibit and/or collect particulates within the annular region **716**. For example, particulates entering the implantable lumen filter **700** by way of the annular region **716** may be collected and/or retained within the annular region **716**. As a result, at least a portion of the particulates collected by the implantable lumen filter **700** can be retained at or near the outer dimension of the body **702**, thereby at least partially maintaining the flow through the central portion of the lumen. By so doing, aspects of the example implantable lumen filter

700 of FIGS. 7A-B can prevent or minimize blockage and/or reduced flow through the lumen, thereby extending the lifespan and enhancing the durability of the implantable lumen filter 700.

The struts 706, 707 of the body 702 may be formed from various materials including nickel titanium and/or alloys thereof, cobalt chromium and/or alloys thereof, other materials, and/or combinations thereof. At least one beneficial agent may be incorporated into the material of and/or coated over at least a portion of the struts 706, 707.

The struts 706, 707 may be welded and/or otherwise connected together. For example, the outer struts 706 may be welded together at the distal end 702b. In addition, the inner struts 707 may be welded to the corresponding outer struts 706 a predetermined distance from the proximal end 702a. In other configurations, the struts 706, 707 may be formed by removing material from the body 702 using, for example, laser cutting and/or other material removing procedures.

The struts 706 may form a plurality of apertures 710 in the body 702. In the configuration illustrated in FIGS. 7A-B, the struts 706, 707 form generally V-shaped apertures 710. The struts 706, 707 may form other shapes, such as diamond shapes, chevron shapes, triangular shapes, and/or other suitable shapes. The struts 706, 707 may form apertures 710, that are generally the same shape, for example generally V-shaped. In other configurations, the struts 706, 707 may form apertures 710 that are different shapes, for example generally V-shaped and generally chevron shaped. In further configurations, the apertures 710 may all be of varying shapes.

The apertures 710 may be spread across various portions of the body 702. The size and/or number of apertures 710 may vary and may be selected to inhibit passage of and/or to lyse particulates of a selected size while allowing blood components smaller than the selected size to pass through said apertures. For instance, a proximal portion of apertures 710 may include generally larger and/or fewer apertures 710 than an intermediate portion and/or distal portion. Such a configuration may capture and/or lyse a variety of particles. In other configurations, the apertures 710 may be distributed over more and/or fewer portions.

In a further embodiment, the implantable lumen filter 700 can be interchangeably deployed within a lumen. For example, the implantable lumen filter 700 can be deployed with either the distal end 702b or the proximal end 702a positioned on the upstream side of the implantable lumen filter 700 within the lumen.

FIGS. 8A-B illustrate another configuration of an implantable lumen filter 800. In FIG. 8A, the implantable lumen filter 800 is shown in flattened form for ease of discussion. FIG. 8B illustrates a cross-sectional view of the implantable lumen filter 800 of FIG. 8A along the line 8B-8B. The implantable lumen filter 800 of this other configuration may be functionally similar to the implantable lumen filters 100, 200, 300, 400, 500, 600, 700 previously described above and shown in FIGS. 1-7 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter 800 may incorporate at least one component of the implantable lumen filters 100, 200, 300, 400, 500, 600, 700, 900, 1000, 1100, and 1200 described in connection with FIGS. 1-7 and 9-12, respectively.

The implantable lumen filter 800 is shown in flattened form for ease of discussion. The implantable lumen filter 800 may

include a body 802 having a proximal end 802a and a distal end 802b. The proximal end 802a may be the end of the body 802 that is closest to a user as the implantable lumen filter 800 is advanced into a body lumen. In other configurations, the proximal end 802a may be the end of the body 802 that is farthest from a user. The body 802 may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 8A-B in the expanded state. The implantable lumen filter 800 may also include one or more retrieval portions 830 coupled to the body 802 for retrieving the body 802 from a lumen.

The body 802 may define an outer surface 804 being defined by a plurality of struts 806. The outer surface 804, in the illustrated configuration, may have a generally tapered shape from the proximal end 802a toward the distal end 802b. The body 802 may include an apex 805 at or near the proximal end 802a. The apex 805 may include an angular or otherwise curved bend in the outer struts 806 proximate the proximal end 802a. The apex 805 may be configured to engage the inner surface of a body lumen to anchor and/or align the body within the lumen.

The implantable lumen filter 800 may include a plurality of inner struts 807 spanning a portion of the outer struts 806 including the apex 805. For example, the inner struts 807 may be attached at one end to the outer struts 806 a distance away from the proximal end 802a and at the other end to the outer struts 806 at the proximal end 802a. The inner struts 807 can extend in a direction generally parallel with the longitudinal axis 801, or can be angled in any direction desired for a particular application. In addition, the number of inner struts 807 included in the body 802, and the position and number of inner struts 807 attached to each outer strut 806 can be varied as desired for each particular application.

The apex 805 may define an outer dimension 812 of the body 802, while the inner struts 807 may at least partially define an inner dimension 813. The outer dimension 812 and inner dimension 813 may define an annular region 816 extending around the body 802 at or near the proximal end 802a. The inner dimension 813 can vary with respect to the outer dimension 812 as desired according to multiple configurations. For example, the inner dimension 813 can range from about 5% to about 95% of the outer dimension 812. In a further example, the inner dimension 813 can range from about 25% to about 75% of the outer dimension 812. In an even further example, the inner dimension 813 can be about half of the outer dimension 812.

The inner struts 807 and/or outer struts 808 may form one or more points 817. The points 817 may be configured to inhibit, lyse, and/or impale particulates flowing within a lumen. The points 817 can be configured to be angled in any direction desired. For example, the points can be angled inward toward the longitudinal axis 801. In further examples, the points 817 can be in parallel with the longitudinal axis 801 or angled outward towards the apex 805.

The implantable lumen filter 800 may be configured to inhibit and/or collect particulates within the annular region 816. For example, particulates entering the implantable lumen filter 800 by way of the annular region 816 may be collected and/or retained within the annular region 816. As a result, at least a portion of the particulates collected by the implantable lumen filter 800 can be retained at or near the outer dimension of the body 802, thereby at least partially maintaining the flow through the central portion of the lumen. By so doing, aspects of the example implantable lumen filter 800 of FIGS. 8A-B can reduce blockage of the lumen, thereby extending the lifespan and enhancing the durability of the implantable lumen filter 800.

In a further embodiment, the implantable lumen filter **800** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **800** can be deployed with either the distal end **802b** or the proximal end **802a** positioned on the upstream side of the implantable lumen filter **800** within the lumen.

FIGS. 9A-B illustrate another configuration of an implantable lumen filter **900**. In FIG. 9A, the implantable lumen filter **900** is shown in flattened form for ease of discussion. FIG. 9B illustrates an end view of the implantable lumen filter **900** of FIG. 9A. The implantable lumen filter **900** of this other configuration may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800** previously described above and shown in FIGS. 1-8 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **900** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **1000**, **1100**, and **1200** described in connection with FIGS. 1-8 and 10-12, respectively.

The implantable lumen filter **900** is shown in flattened form for ease of discussion. The implantable lumen filter **900** may include a body **902** having a proximal end **902a** and a distal end **902b**. The proximal end **902a** may be the end of the body **902** that is closest to a user as the implantable lumen filter **900** is advanced into a body lumen. In other configurations, the proximal end **902a** may be the end of the body **902** that is farthest from a user. The body **902** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 9A-B in the expanded state. The implantable lumen filter **900** may also include one or more retrieval portions **930** coupled to the body **902** for retrieving the body **902** from a lumen.

The body **902** may define an outer surface **904** being defined by a plurality of struts **906**. The outer surface **904**, in the illustrated configuration, may have a generally tapered shape from the proximal end **902a** toward the distal end **902b**. The body **902** may include an apex **905** at or near the proximal end **902a**. The apex **905** may include an angular or otherwise curved bend in the outer struts **906** proximate the proximal end **902a**. The apex **905** may be configured to engage the inner surface of a body lumen to anchor and/or align the body within the lumen.

The implantable lumen filter **900** may include a plurality of inner struts **907** extending from the outer struts **906**. For example, the inner struts **907** may be attached to the outer struts **906** a distance away from the proximal end **902a**. The inner struts **907** can extend in a direction generally parallel with the longitudinal axis **901**, or can be angled in any direction desired for a particular application. In addition, the number of inner struts **907** included in the body **902**, and the position and number of inner struts **907** attached to each outer strut **906** can be varied as desired for each particular application.

The outer struts **906** may include an outer ring **909a** extending around the body **902** at or near the proximal end **902a** and connecting the longitudinally-extending outer struts **906**. The inner struts **907** may include by a corresponding inner ring **909b** extending around and connecting the free ends of the inner struts **907**.

The outer struts **906** and/or outer ring **909a** may at least partially define an outer dimension **912** of the body **902**, while the inner struts **907** and/or inner ring **909b** may at least par-

tially define an inner dimension **913**. The outer dimension **912** and inner dimension **913** may define an annular region **916** at or near the proximal end **902a** of the body **902**. The inner dimension **913** can vary with respect to the outer dimension **912** as desired according to multiple configurations. For example, the inner dimension **913** can range from about 5% to about 95% of the outer dimension **912**. In a further example, the inner dimension **913** can range from about 25% to about 75% of the outer dimension **912**. In an even further example, the inner dimension **913** can be about half of the outer dimension **912**.

The rings **909** may include one or more points **917**. The points **917** may be configured to inhibit, lyse, and/or impale particulates flowing within a lumen. As shown in the illustrated configuration, the points **917** can be angled inward toward the longitudinal axis **901**. In a further example, the points **917** can be angled in any direction desired, such as in parallel with the longitudinal axis **901** or outward towards the apex **905**.

Aspects of the example implantable lumen filter **900** may be result in the inhibition or collection of particulates within the annular region **916**. For example, particulates entering the implantable lumen filter **900** by way of the annular region **916** may be collected and/or retained within the annular region **916** by the outer struts **906**, inner struts **907**, and/or outer and inner rings **909a**, **909b**. As a result, at least a portion of the particulates collected by the implantable lumen filter **900** can be retained at or near the outer dimension of the body **902**, thereby at least partially maintaining the flow through the central portion of the lumen. By so doing, aspects of the example implantable lumen filter **900** of FIGS. 9A-B can extend the lifespan and enhance the durability of the implantable lumen filter **900**.

In a further embodiment, the implantable lumen filter **900** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **900** can be deployed with either the distal end **902b** or the proximal end **902a** positioned on the upstream side of the implantable lumen filter **900** within the lumen.

FIGS. 10A-B illustrate another configuration of an implantable lumen filter **1000**. In FIG. 10A, the implantable lumen filter **1000** is shown in flattened form for ease of discussion. FIG. 10B illustrates an end view of the implantable lumen filter **1000** of FIG. 10A. The implantable lumen filter **1000** of this other configuration may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **1000** previously described above and shown in FIGS. 1-9 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **1000** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1100**, and **1200** described in connection with FIGS. 1-9 and 11-12, respectively.

The implantable lumen filter **1000** is shown in flattened form for ease of discussion. The implantable lumen filter **1000** may include a body **1002** having a proximal end **1002a** and a distal end **1002b**. The proximal end **1002a** may be the end of the body **1002** that is closest to a user as the implantable lumen filter **1000** is advanced into a body lumen. In other configurations, the proximal end **1002a** may be the end of the body **1002** that is farthest from a user. The body **1002** may be transitionable from a compressed state toward an expanded state and is shown in the FIGS. 10A-B in the expanded state.

The implantable lumen filter **1000** may also include one or more retrieval portions **1030** coupled to the body **1002** for retrieving the body **1002** from a lumen.

The body **1002** may define an outer surface **1004** being defined by a plurality of outer struts **1006**. The outer surface **1004**, in the illustrated configuration, may have a generally tapered shape from the proximal end **1002a** toward the distal end **1002b**. The body **1002** may include an apex **1005** at or near the proximal end **1002a**.

The body **1002** may include a plurality of inner struts **1007** extending from the outer struts **1006**. For example, the inner struts **1007** may be attached at one end to the outer struts **1006** a distance away from the proximal end **1002a** and at the other end to the outer struts **1006** at the proximal end **1002a**. The inner struts **1007** can extend in a direction generally parallel with the longitudinal axis **1001**, or can be angled in any direction desired for a particular application. In addition, the number of inner struts **1007** included in the body **1002**, the size, shape, and/or length of each inner strut **1007**, and the position and number of inner struts **1007** attached to each outer strut **1006** can be varied as desired for each particular application.

The outer struts **1006** may at least partially define an outer dimension **1012** of the body **1002**, while the inner struts **1007** may at least partially define an inner dimension **1013**. The outer dimension **1012** and inner dimension **1013** may define an annular region **1016** extending around the body **1002** at or near the proximal end **1002a**. The inner dimension **1013** can vary with respect to the outer dimension **1012** as desired according to multiple configurations. For example, the inner dimension **1013** can range from about 5% to about 95% of the outer dimension **1012**. In a further example, the inner dimension **1013** can range from about 25% to about 75% of the outer dimension **1012**. In an even further example, the inner dimension **1013** can be about half of the outer dimension **1012**.

The body **1002** may further include one or more rings **1009** at or near the proximal end **1002a**. In the present example configuration, the rings **1009** can interconnect the plurality of outer struts **1006** and the plurality of inner struts. In addition, the rings **1009** can at least partially define the annular region **1016**.

The rings **1009** may also form a plurality of apertures **1010** in the annular region **1016**. In the configuration illustrated in FIGS. 10A-B, the rings **1009** form generally diamond shaped and triangular shaped apertures **1010**. The rings **1009** and/or struts **1006**, **1007** may also form apertures of other shapes.

The rings **1009** and/or inner struts **1007** may form one or more points **1017**. The points **1017** may be configured to inhibit, lyse, and/or impale particulates flowing within a lumen. As shown in the illustrated configuration, the points **1017** can be angled inward toward the longitudinal axis **1001**. In a further example, the points **1017** can be angled in any direction desired, such as in parallel with the longitudinal axis **1001** or outward towards the apex **1005**.

The implantable lumen filter **1000** may be configured to inhibit and/or collect particulates within the annular region **1016**. For example, particulates entering the implantable lumen filter **1000** by way of the annular region **1016** may be collected and/or retained within the annular region **1016**. As a result, at least a portion of the particulates collected by the implantable lumen filter **1000** can be retained at or near the outer dimension of the body **1002**, thereby at least partially maintaining the flow through the central portion of the lumen. By so doing, aspects of the example implantable lumen filter **1000** of FIGS. 10A-B can extend the lifespan and enhance the durability of the implantable lumen filter **1000**.

In a further embodiment, the implantable lumen filter **1000** can be interchangeably deployed within a lumen. For example, the implantable lumen filter **1000** can be deployed with either the distal end **1002b** or the proximal end **1002a** positioned on the upstream side of the implantable lumen filter **1000** within the lumen.

FIG. 11 illustrates an exemplary subject **1150** for an implantable lumen filter **1100**. The implantable lumen filter **1100** may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1000** previously described above and shown in FIGS. 1-10 in most respects, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into the configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter **1100** may incorporate at least one component of the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1000**, and **1200** described in connection with FIGS. 1-10 and 12, respectively.

Although many of the embodiments herein may describe an implantable lumen filter **1100**, other filters may be deployed and/or retrieved using at least one embodiment of a filter retrieval system described herein. The filter **1100** may be implanted in a body lumen **1152** of the subject **1150**. The filter **1100** may be inserted and/or retrieved through an access site **1154a**, **1154b**, **1154c**. In the present embodiment, the access site may include a femoral artery access site **1154a**, a jugular vein access site **1154b**, a radial vein access site **1154c**, femoral vein, brachial vein, brachial artery, other access sites, or combinations thereof. For instance, the filter **1100** may be inserted through the femoral artery access site **1154a** and retrieved through the jugular or radial vein access site **1154b**, **1154c**. In another example, the filter **1100** may be inserted through the jugular vein access site **1154b** and retrieved through the femoral artery or radial vein access site **1154a**, **1154c**. In a further example, the filter **1100** may be inserted through the radial vein access site **1154c** and retrieved through the femoral artery or jugular vein access site **1154a**, **1154b**.

The filter **1100** may be inserted and retrieved through the radial vein access site **1154c**. Additionally, the filter **1100** may be inserted and retrieved through the jugular vein access site **1154b**. Further, the filter **1100** may be inserted and retrieved through the femoral artery access site **1154a**.

The filter **1100** may be deployed near a deployment site **1156**. In the present embodiment, the deployment site **1156** may include a location within the inferior vena cava. In other embodiments, other deployment sites may be used, such as the superior vena cava. For example, the deployment site **1156** may include all larger veins.

As mentioned above, some body lumen filters typically use jugular, antecubital, or other access sites for retrieval because they are typically not configured to be retrieved through the femoral access. Retrieval through the same access site through which the filter was deployed may be desired. At least one embodiment of a filter retrieval system may provide for retrieval through the same access site through which the filter was deployed.

FIGS. 12A-12G illustrate various steps in the deployment of an implantable lumen filter **1200**. The implantable lumen filter **1200** may be functionally similar to the implantable lumen filters **100**, **200**, **300**, **400**, **500**, **600**, **700**, **800**, **900**, **1000**, **1100** previously described above and shown in FIGS. 1-11 in most respects, wherein certain features will not be described in relation to this configuration wherein those com-

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ponents may function in the manner as described above and are hereby incorporated into the configuration described below. Like structures and/or components are given like reference numerals. Additionally, the implantable lumen filter 1200 may incorporate at least one component of the implantable lumen filters 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, and 1100 described in connection with FIGS. 1-11, respectively.

FIG. 12A illustrates a deployment site 1256 within a body lumen 1252 with a guidewire 1261 partially inserted there-through. The guidewire 1261 may be inserted through an access site (shown as 1154a, 1154b, 1154c in FIG. 11) toward the deployment site 1256. The guidewire 1261 may be used to locate the deployment site 1256. In other configurations, other methods may be used in addition to or instead of a guidewire 1261. For example, an imaging device, such as a fluoroscope, x-ray, and/or other imaging device may be used to locate the deployment site 1256.

As shown in FIG. 12B, a delivery apparatus 1260 may use the guidewire 1261 to guide a distal end 1260b of the delivery apparatus 1260 toward the delivery site 1256. An implantable lumen filter 1200 may be disposed within the delivery apparatus 1260. The implantable lumen filter 1200, in the illustrated configuration, may be disposed within the delivery apparatus 1260 while in a collapsed state. While in the collapsed state, the implantable lumen filter 1200 may be longitudinally elongated with respect to a deployed state.

The guidewire 1261 may be removed after the distal end 1260b of the delivery apparatus 1260 is located near the delivery site 1256. Alternatively, the guidewire 1261 may remain.

A deployment member 1262 may be inserted through the delivery apparatus 1260, as shown in FIG. 12C. The deployment member 1262 may be used to deploy the implantable lumen filter 1200. In the configuration shown in FIG. 12D, the deployment member 1262 may urge the implantable lumen filter 1200 toward the distal end 1260b of the delivery apparatus 1260 while the delivery apparatus 1260 may remain generally stationary.

The deployment member 1262 may urge the implantable lumen filter 1200 by abutting the proximal end 1202a of the filter 1200. The deployment member 1262 may include a receiving area (not shown), such as a convex portion configured and dimensioned to receive the proximal end 1202a, to facilitate urging the implantable lumen filter 1200 out of the delivery apparatus 1260.

In the configuration shown in FIG. 12D', the delivery apparatus 1260 may be retracted while the deployment member 1262 may remain generally stationary. In other configurations, the delivery apparatus 1260 and/or the deployment member 1262 may cooperate to facilitate deployment of the implantable lumen filter 1200. For instance, the delivery apparatus 1260 may be retracted while the deployment member 1262 may urge the implantable lumen filter 1200 toward the distal end 1260b of the delivery apparatus 1260.

FIG. 12E illustrates a deployed implantable lumen filter 1200 within the body lumen 1252. In the deployed configuration, the implantable filter 1200 may engage an inside surface 1253 of the body lumen 1252. The apex 1205 of the implantable lumen filter may engage the inside surface 1253 of the body lumen 1252. In the deployed configuration, the implantable lumen filter 1200 may be longitudinally reduced with respect to a collapsed configuration.

The implantable lumen filter 1200' shown in FIGS. 12F-12G may include a retrieval portion 1230' near the distal end 1202b' of the implantable lumen filter 1200'. The retrieval

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portion 1230' may be operatively connected to the distal end 1202b' of the implantable lumen filter 1200'.

The implantable lumen filter 1200' may be engaged by a retrieval member 1264. The retrieval member 1264 may include a retrieving mechanism 1266, such as a hook and/or other retaining mechanism, configured to engage the retrieval portion 1230'.

Upon engaging the retrieval portion 1230', the retrieval member 1264 may urge the implantable lumen filter 1200' into the retrieval apparatus 1263. For example, urging the implantable lumen filter 1200' toward the retrieval apparatus 1263 may facilitate disengaging the apex 1205'.

In the illustrated configuration, the retrieval apparatus 1263 and the retrieval member 1264 may both move in generally opposite directions to urge the implantable lumen filter 1200' into the retrieval apparatus 1263 into a compressed state, such that the implantable lumen filter 1200' may be longitudinally elongated with respect to a deployed state, as shown in FIG. 12G.

The implantable lumen filter 1200" shown in FIGS. 12F'-12G' is shown with a retrieval portion 1230" near the proximal end 1202a" of the implantable lumen filter 1200".

The implantable lumen filters 1200" may be engaged by a retrieval member 1264. The retrieval member 1264 may include a retrieving mechanism 1266, such as a hook and/or other retaining mechanism, configured to engage the retrieval portion 1230".

Upon engaging the retrieval portion 1230", the retrieval member 1264 may limit motion away from the retrieval member 1264. In the illustrated configuration, the retrieval member 1264 may remain generally stationary while the retrieval apparatus 1263 is advanced to urge the implantable lumen filter 1200" into the retrieval apparatus 1263. For example, advancing the retrieval apparatus 1263 may facilitate disengaging the apex 1205".

In the present configuration, the retrieval member 1264 remains generally stationary while the retrieval apparatus 1263 moves to urge the implantable lumen filter 1200" into the retrieval apparatus 1263 into a compressed state, such that the implantable lumen filter 1200" may be longitudinally elongated with respect to a deployed state, as shown in FIG. 12G'. In other configurations, both the retrieval apparatus 1263 and the retrieval member 1264 may move in generally opposite directions.

After the implantable devices 1200, 1200', 1200" are within the retrieval apparatus 1263, the retrieval apparatus 1263 and implantable devices 1200, 1200', 1200" may be withdrawn through an access site (shown as 1154a, 1154b in FIG. 11).

The invention is susceptible to various modifications and alternative means, and specific examples thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the invention is not to be limited to the particular devices or methods disclosed, but to the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the claims.

We claim:

1. An implantable lumen filter, comprising:
a body comprising:

a proximal portion having a generally-tapered outer surface, the outer surface of the proximal portion being defined by a plurality of elongated outer struts coupled together at a proximal end of the proximal portion and tapering outward towards a distal end of the proximal portion, adjacent outer struts of the

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proximal portion defining v-shaped apertures in the outer surface of the proximal portion;

a distal portion having a generally-tapered outer surface, the outer surface of the distal portion being defined by a plurality of elongated outer struts coupled together at a distal end of the distal portion and tapering outward away from each other towards a proximal end of the distal portion, the proximal end of the distal portion being coupled to the distal end of the proximal portion;

an apex joining the distal end of the proximal portion and the proximal end of the distal portion to form the body, and defining an outer dimension of the body, and

a plurality of inner struts, the plurality of inner struts connect to the plurality of outer struts of the distal portion, extend across the apex, and connect with the plurality of outer struts of the proximal portion;

wherein at least one of the proximal and distal portions terminates at a hook configured for deploying or removing the body.

2. The implantable filter of claim 1, the body being transitionable from a collapsed state to a deployed state.

3. The implantable lumen filter of claim 1, the number and position of the outer struts of the proximal portion being selectively chosen to produce apertures of a selected size.

4. The implantable lumen filter of claim 1, further comprising a plurality of overhanging struts at least partially defining an annular region extending around the body proximate the apex.

5. The implantable lumen filter of claim 4, wherein the annular region is configured to collect, inhibit, or lyse particulates within a body lumen.

6. The implantable lumen filter of claim 1, at least a portion of the struts of the body including cobalt chromium and/or alloys thereof.

7. The implantable lumen filter of claim 1, at least a portion of the body being coated with a thrombo-resistant coating.

8. The implantable lumen filter of claim 1, in which the proximal portion and the distal portion are substantially symmetrical about a plane defined by the apex.

9. The implantable lumen filter of claim 8, wherein the proximal portion and the distal portion have opposing substantially conical shapes.

10. The implantable lumen filter of claim 1, the plurality of inner struts at least partially defining an inner dimension, the outer dimension and the inner dimension at least partially defining an annular region extending around the body proximate the apex.

11. The implantable lumen filter of claim 10, wherein the annular region is configured to collect, inhibit, or lyse particulates within a body lumen.

12. The implantable lumen filter of claim 1, the proximal portion being configured to direct particulates within a lumen radially outwards towards the outer dimension when the body is deployed within the lumen.

13. A method for filtering a body lumen, the method comprising:

longitudinally elongating an implantable lumen filter such that the implantable lumen filter has a reduced dimension, the implantable lumen filter including a body comprising:

a proximal portion having a generally-tapered outer surface, the outer surface of the proximal portion being defined by a plurality of elongated outer struts coupled together at a proximal end of the proximal portion and tapering outward towards a distal end of

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the proximal portion, adjacent outer struts of the proximal portion defining v-shaped apertures in the outer surface of the proximal portion;

a distal portion having a generally-tapered outer surface, the outer surface of the distal portion being defined by a plurality of elongated outer struts coupled together at a distal end of the distal portion and tapering outward towards a proximal end of the distal portion, the proximal end of the distal portion being coupled to the distal end of the proximal portion; and

an apex extending around the body proximate the distal end of the proximal portion and defining an outer dimension of the body;

a plurality of inner struts, the plurality of inner struts connect to the plurality of outer struts of the distal portion, extend across the apex, and connect with the plurality of outer struts of the proximal portion;

wherein at least one of the proximal and distal portions terminates at a hook configured for deploying or removing the body;

delivering the implantable lumen filter to a desired deployment site within the body lumen; and

longitudinally reducing the implantable lumen filter such that the implantable lumen filter has an enlarged outer dimension and applies radial force to an inner wall of the body lumen.

14. An implantable lumen filter, comprising:

a body comprising:

a proximal portion having a generally-tapered outer surface, the outer surface of the proximal portion being defined by a plurality of elongated outer struts coupled together at a proximal end of the proximal portion and tapering outward towards a distal end of the proximal portion, adjacent outer struts of the proximal portion defining v-shaped apertures in the outer surface of the proximal portion, the proximal portion terminating in a hook configured for deploying or removing the body, the distal end of at least one outer strut of the proximal portion being angled in a direction transverse to a longitudinal axis of the body and a remainder of the outer strut;

a distal portion having a generally-tapered outer surface, the outer surface of the distal portion being defined by a plurality of elongated outer struts coupled together at a distal end of the distal portion and tapering outward towards a proximal end of the distal portion, the proximal end of the distal portion being coupled to the distal end of the proximal portion, the distal portion terminating in a hook configured for deploying or removing the body;

an apex extending around the body and defining an outer dimension of the body; and

a plurality of inner struts, the plurality of inner struts connect to the plurality of outer struts of the distal portion, extend across the apex, and connect with the plurality of outer struts of the proximal portion;

an annular region extending around the body proximate the apex, the annular region being configured to collect, inhibit, and/or lyse particulates within a lumen, the annular region being at least partially defined by the outer dimension, the proximal portion being configured to direct particulates within a lumen radially outwardly towards the annular region when the body is deployed within the lumen with the proximal portion being deployed on the upstream side of the body.

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